Universidad Autónoma de Madrid
Facultad de Ciencias Económicas y Empresariales

Tesis doctoral

Essays on macroprudential and fiscal policy in a currency union

María Malmierca Ordoqui

Supervisor: Beatriz de Blas Pérez

Madrid, October, 2019

Universidad Autónoma de Madrid
Facultad de Ciencias Económicas y Empresariales

Tesis doctoral

Essays on macroprudential and fiscal policy in a currency union

María Malmierca Ordoqui

Supervisor: Beatriz de Blas Pérez

Madrid, October, 2019

Abstract

The main objective of this doctoral dissertation is to provide a complete analysis of the stabilization role of macroprudential policies in diverse economic scenarios. To that aim, the dissertation is divided into three different chapters. Chapter 1 is motivated by the fact that, after the financial crisis of 2007. and as opposed to pre-2007 evidence, public and private debt have moved in opposite directions in most economies. I refer to this negative relation as *private-public debt channel*. In a new Keynesian model with financial frictions, I show that when a credit risk shock hits the economy, the channel amplifies the response of GDP. In this setup, the traditional monetary-fiscal policy mix is not enough to offset this channel and therefore bring back economic stability. The main result of this chapter is that, when macroprudential policy is part of the policy mix, this channel can be broken. Interestingly, depending on the macroprudential instrument considered, a trade-off may arise between private debt and output stabilization. The second chapter studies different macroprudential policy implementations in a two-country DSGE model for a monetary union. The objective is to evaluate which design of macroprudential policy might attain the greatest stability after an asymmetric credit risk shock. This analysis shows that macroprudential policies implemented at the national level entail macroeconomic and financial stability for both countries. However, macroprudential policies implemented at the union level, bring larger macroeconomic stability to the country that suffers the shock, while they destabilize other country. Finally, the third and last chapter of the dissertation provides a normative analysis for macroprudential policy. I evaluate the optimal macroprudential policy, both in terms of enhancing stabilization and welfare, and the desirability to coordinate it with optimal fiscal policy. I find that, in the event of financial shocks, the optimal macroprudential policy always achieves welfare gains. Under technology shocks, the optimal macroprudential policy implies a welfare deterioration. And, after preference shocks, the optimal scenario usually consists of not implementing macroprudential policy.

Keywords: Policy interaction, Public and private debt, Currency area, Welfare, Stabilization.

JEL Codes: E44, E62, E63, F42, F45.

Resumen (Spanish)

El principal objetivo de esta tesis doctoral es proporcionar un análisis completo sobre la función estabilizadora de la política macroprudencial en diversos escenarios económicos. Con ese objetivo, la tesis se divide en tres capítulos. El Capítulo 1 está motivado por el hecho de que, tras la crisis financiera de 2007, y en contra de la evidencia anterior, las deudas pública y privada han seguido direcciones opuestas en muchas economías. Denomino a esta relación negativa *canal de deuda privada-pública*. Mediante un modelo nuevo Keynesiano con fricciones financieras muestro que, cuando una perturbación del riesgo de crédito golpea la economía, el canal amplifica la respuesta del PIB. En esta situación, el tradicional conjunto de políticas monetaria y fiscal no es suficiente para anular el canal y, por tanto, restaurar la estabilidad económica. El principal resultado de este capítulo es que, cuando la política macroprudencial es parte del conjunto de políticas, puede romperse el canal. Resulta interesante que, dependiendo del instrumento macroprudencial considerado, aflora un intercambio entre la estabilización de la deuda privada y de la producción. El segundo capítulo estudia diferentes implementaciones de política macroprudencial en un modelo DSGE de dos países para una unión monetaria. El objetivo es evaluar qué diseño de política macroprudencial podría alcanzar la mayor estabilidad tras una perturbación asimétrica de riesgo de crédito. Este análisis muestra que las políticas macroprudenciales implementadas a nivel nacional conllevan estabilidad macroeconómica y financiera para ambos países. Sin embargo, las políticas macroprudenciales implementadas a nivel de la unión, traen consigo una mayor estabilidad macroeconómica para el país que sufre la perturbación, mientras que desestabilizan el otro país. Finalmente, el tercer y último capítulo de la tesis proporciona un análisis normativo para la política macroprudencial. Se evalúa la política macroprudencial óptima, tanto en términos de estabilización como de mejora del bienestar, y la conveniencia de coordinarla con la política fiscal óptima. En el supuesto de perturbaciones financieras, obtengo que la política macroprudencial óptima logra siempre ganancias de bienestar. Bajo perturbaciones tecnológicas, la política macroprudencial óptima implica un deterioro del bienestar. Y, tras una perturbación en las preferencias, el escenario más óptimo habitualmente consiste en la no implementación de política macroprudencial.

Palabras clave: Interacción de políticas, Deuda pública y privada, Unión monetaria, Bienestar, Estabilización.

Códigos JEL: E44, E62, E63, F42, F45.

Acknowledgement

First of all, I am immensely thankful to my supervisor, Beatriz de Blas Pérez, for her extraordinary guidance and patience throughout these intense years of work. I greatly benefited from her comments and advice, both intellectually and personally. She is and will continue to be a role model for me.

I also thank two anonymous referees from Economic Modelling for all their valuable comments and suggestions on the first chapter of my dissertation.

I would like to express my sincere gratitude to all the professors of the department Análisis Económico: Teoría e Historia Económica de la Universidad Autónoma de Madrid. Their suggestions have made my thesis much better.

I am greatly indebted to the Banco de España, that provided me and excellent research environment, and where I did not stop learning through seminars and from the team I worked with. In particular, I want to thank Carlos Thomas and Alessandro Galesi.

I am also thankful for the helpful insights and comments at the 43rd Simposio de la Asociación Española de Economía (SAEe 2018) and the XX Conference on International Economics organized by the Asociación Española de Economía y Finanzas Internacionales (AEEFI).

Finally, I am especially grateful to my family. To my parents, who have always accepted and believed in my decisions. They, with all their love, have been essential for me to keep working hard. To my sisters and brothers and to my husband's family, who have always cheered me up. I also thank my son Pablo and my daughter Elena, who made me smile even in the bad moments, bringing color to my PhD life. Last, and most importantly, I want to thank my husband, Pablo. His support did this journey much easier. He encouraged me to starting this project in the first place and to making it to the end. Definitely, this would never have been possible without him. Thanks to you all.

Contents

List of Figures

List of Tables

Introduction

Macroprudential policy has acquired an enormous importance in advance economies (emerging countries were already using them), especially since the severe financial recession of 2007 and its posterior scope. This policy consists of a new economic tool that complements the traditional policies ensuring stability in the financial system, which is key to maintain a stable economy.

Both the most convenient way of implementing macroprudential policy and the macroprudential instruments that should be used are part of a debate that still remains open. The European Systemic Risk Board (ESRB) recommends macroprudential authorities, in order to achieve the ultimate objective of macroprudential policy, which is the safeguard of the financial system as a whole, to pursue certain intermediate objectives addressing their national financial systems (ESRB/2013/1). The intermediate objectives seek to mitigate the credit and private leverage growth, to prevent the excessive maturity mismatch and market illiquidity, to limit direct and indirect exposure concentrations, to limit the systemic impact of misaligned incentives, to reduce moral hazard and to strengthen the financial infrastructures. The fulfillment of these intermediate objectives would ensure a more resilient financial system and reduce the systemic risk accumulation.

Monetary policy has also been oriented on some occasions to the control of the financial system, but there are some studies, such as Lambertini, Mendicino and Punzi (2013), explaining that this is not the option which delivers the greatest stabilization. On the one hand, monetary policy is not as effective as macroprudential policy in the accomplishment of the above explained objectives. On the other hand,

it is not convenient to deviate monetary policy from its main objective, the pursue of price stability. This is why it is necessary to introduce macroprudential policies as part of the economic policy mix.

It is worth mentioning that macroprudential policy is facing important challenges mainly due to the limited experience in its use. Moreover, there are still several questions and unknowns related to macroprudential policy that time will take care of answering, among others, the side effects that these measures might entail. However, it is undeniable that its use is growing exponentially, and that macroprudential policy is becoming an essential pillar in the economic policy mix.

This doctoral dissertation analyzes the use of macroprudential policy through Dynamic Stochastic General Equilibrium models (DSGE) and aims at providing a new approach for its study, complementing the existing macroprudential literature. In particular, my macroprudential tool, based on Quint and Rabanal (2014), affects the supply of loans in an equivalent way to capital requirements, reserve requirements or loan-loss dynamic provisions, implemented in the real-world (see Cerutti et al., 2015 or Lim et al., 2011).

Macroprudential policy implementation in my model is countercyclical. There are a great number of empirical studies on the effectiveness of countercyclical macroprudential polices. Among others, Cerutti et al. (2015) find that macroprudential policy significantly mitigates credit developments, what implies financial system stability. These authors analyze the increasing use of macroprudential instruments, over the period 2000-2013. Reserve requirements are present in 21% of the total combination of instruments used throughout the years under analysis and by the whole set of 119 advanced, developing and emerging countries of their sample. Loan-loss provisions represent around 9% of the total set. Capital requirements are about 2% according to their study. The cross-country regression analysis of Lim et al. (2011) suggests that many of the most frequently used macroprudential instruments are effective in reducing the procyclicality of credit. They remark the advantages of rule-based macroprudential instruments that are automatically adjusted to counter the cyclicality of credit, as an "automatic stabilizer". However, their analysis is sen-

sitive to the type of shock facing the financial sector. Some examples of this type of measures are dynamic provisioning and the capital conservation buffer under Basel III. The authors also point out that countries introducing reserve requirements reduced the procyclicality of credit and that dynamic provisioning instruments inverted the correlation between credit and GDP growth. In my dissertation, I use a macroprudential tool based on a rule that allows to smooth the cycle and operates in an equivalent way to these effective macroprudential instruments.

In this dissertation the use of macroprudential policy pursues the ultimate goal of achieving financial and economic stability in an economy where a shock deviates the economic variables from their steady state. The main analysis of this thesis is based on the event of a financial shock consisting of a credit risk increase in the private sector that destabilizes the economy, similar to the one in the Great Recession. The motivation for this research revolving around this financial shock lies in the argument of Christiano, Motto and Rostagno (2010) who find these credit risk shocks responsible for great part of the business cycle fluctuations.

The financial shock generates a channel in the model studied in this dissertation that connects private debt and public debt negatively, contributing to an even greater destabilization. This *private-public debt channel* works in the following way. After a financial shock, that increases private credit risk, GDP goes down. *Ceteris paribus*, this fall of GDP reduces public revenues coming from the collection of taxes what leads to an increase of public debt. At the same time, the shock toughens the financial conditions to the private sector, raising the interest rate on loans. Thus, both the supply and the demand for private debt go down what implies a fall of private investment and a further GDP decrease. This is how a negative correlation between private debt and public debt appears, generating the above-mentioned channel. Therefore, the channel amplifies the fall of GDP after this type of financial shock. As the origin of the economic destabilization in the present analysis lies in the private-public debt channel, in the event of these financial shocks, it is necessary to find a way to smooth it. One possible way to offset the channel consists of including macroprudential policy in the model. This is why my dissertation

performs a detailed analysis of macroprudential policy, taking into account the different manners of implementing it, its interaction with other policies and the effects of macroprudential policy when other shocks hit the economy.

The main novelty of this research lies on the fact that it focuses on the interaction between fiscal policy and macroprudential policy. What motivates the interest for the fiscal and macroprudential interplay in my thesis is that, in the context of a monetary union, these are the tools on which national authorities can count on to meet their own stabilization needs. The interaction between both policies allows to stabilize public debt and private debt at the same time, and consequently the global economy. Hence, the dissertation is focused on how fiscal policy, in charge of public debt stability, is complemented with macroprudential policy, in charge of private debt stability. This analysis takes on particular significance in the context of a monetary union where monetary policy cannot be used by national authorities to support fiscal policy in its economic stabilization role.

A deep analysis of macroprudential policy requires the observation of a wide variety of issues. First of all, there is a broad range of macroprudential instruments that can be introduced as new tools for the corresponding authorities. The first part of the dissertation analyzes this particular area. Using a DSGE model for a closed economy, based on the one developed by Fernández-Villaverde (2010), I compare how different macroprudential policy implementations affect the economy after a financial shock consisting of a credit risk increase. The macroprudential instrument controls the amount of loans that banks can supply to the private sector. Macroprudential policy is introduced either as the obligation for banks to keep, without lending, part of the funds they receive in their balance sheets, or as the grant to banks to lend more funds than the amount of deposits they get. As it has already been mentioned above, the equivalent instrument in the real economy is a reserve or capital requirement when macroprudential policy is tightening, and a direct provision of liquidity to banks (through conventional or unconventional measures) when macroprudential policy is easing. To ease or tighten the macroprudential instrument, macroprudential authorities should consider a set of financial

indicators depending on the objectives they pursue. Therefore, the first chapter of this thesis compares the implementation of two macroprudential measures, differentiated by the financial indicator they target. In line with Quint and Rabanal (2014), one of the measures reacts to changes in the nominal private credit growth and the other one stabilizes the private debt-to-GDP ratio.

Furthermore, this part of the dissertation includes different fiscal and monetary policies combinations, based on Leeper, 1991, establishing two scenarios for analysis: one of active fiscal and passive monetary policy and another of passive fiscal and active monetary policy. According to Leeper, 1991, passive policies are the ones responsible for stabilizing public debt and balance the government budget. In the analysis of this thesis and also following the Leeper, 1991 approach, active monetary policy stabilizes inflation and active fiscal policy reacts to GDP fluctuations instead of public leverage fluctuations. These two scenarios, in turn, yield different results for each of the two macroprudential policy implementations considered in the first chapter of the thesis. There are also other studies, such as Gomes and Seoane (2018), that also include this categorization of fiscal and monetary active and passive policies. However, I combine macroprudential policy with these active and passive policy scenarios and compare the effects of the shock between different cases with or without macroprudential policy.

The results obtained from this first analysis suggest that the traditional economic policies (fiscal and monetary) cannot offset the private-public debt channel. Therefore, fiscal and monetary policies do not manage to stabilize the economy, independently of how the combination of active/passive fiscal-monetary polices is designed. However, the use of macroprudential policies always cancels the channel responsible for the destabilization in response to a credit risk shock. By offsetting the channel, macroprudential policy contributes either to financial stability (when it reacts to changes in the private debt-to-GDP ratio) or to macroeconomic stability (when it reacts to changes in the nominal private credit growth), independently of how the combination of active/passive fiscal-monetary policies is designed.

Secondly, another part of the literature analyzing macroprudential policy has fo-

cused on its effects on a monetary union (see, for instance, Quint and Rabanal, 2014; Brzoza-Brzezina, Kolasa and Makarski, 2013; or Rubio, 2014). This motivates the analysis of the second part of the doctoral dissertation that implements macroprudential policy in a two-country DSGE model for a monetary union. The model includes an international goods market and an international incomplete financial market connecting both countries. In this occasion, the fiscal and monetary policy scenario considered consists of the combination of passive fiscal policies (stabilizing public debt, in line with Leeper, 1991) and an active monetary policy (stabilizing inflation, in line with Leeper, 1991). According to Leith and Wren-Lewis (2006), a requirement for the existence of equilibrium in a monetary union is to combine an active monetary policy with passive fiscal policies.

In this part of the dissertation, the above-mentioned scenario of monetary and fiscal policy is combined with different implementations of macroprudential policy. These implementations always consist of controlling the funds that banks can lend through an instrument that reacts to nominal credit growth. The analysis compares the effects of macroprudential policy set at the national level with the effects macroprudential policy set at the union level, in a similar way to Dehmej and Gambacorta (2017).

The analysis in this second chapter, considers that a financial shock implying an increase in credit risk is originated in one of the countries belonging to the monetary union. The other country of the union is affected by the shock only indirectly. Again, the private-public debt channel that destabilizes the economy arises, but there is also an additional channel in this model: the *open economy channel*. This channel works due to the expenditure switching effect (see, for instance, Engel, 2003; Galí and Monacelli, 2003; or Corsetti, 2007). The most relevant outcome of this chapter is that when national macroprudential policy is implemented, it is possible to achieve financial and macroeconomic stability in both countries, due to the cancellation of the private-public debt channel. However, when macroprudential policy is implemented at the union level, the country responsible for the shock attains even greater stability, due to the open economy channel, while the country

not suffering directly the effects of the shock is destabilized.

The scenarios for a monetary union in Chapter 2 assume that both countries agree to implement macroprudential policy and, even when it is set at the national level, each of them stabilizes its own credit variables, but following the same macroprudential rule. However, as explained by Rubio and Carrasco-Gallego (2016), it could be the case that countries in the union do not coordinate in the implementation of macroprudential policy. This is why my analysis considers the case in which one of the countries does not implement macroprudential policy while the other does. Moreover, this second part of my research also provides a robustness analysis that studies the situations in which different shocks hit one of the countries and how the economies react to the different macroprudential policy implementations described.

The first two chapters of this dissertation are focused on the comparison of the use of different macroprudential instruments and ways of implementing macroprudential policy as well as their combination with the traditional economic policies. Both analysis are purely positive, not normative, so they do not analyze which is the best option when deciding how to apply macroprudential policy. This is why the last part of the dissertation consists of an optimal policy analysis that studies the desirability of implementing one or another scenario of macroprudential policy based on the pursued objectives.

The main novelty in the third chapter is that it analyzes the optimal macroprudential and optimal fiscal policy interaction within a monetary union. Most of the literature that performs similar analysis for monetary unions is focused on how optimal fiscal and monetary policies coordinate (some examples are Galí and Monacelli, 2005; or Ferrero, 2005). However, during the last years a growing interest in the interaction between optimal macroprudential policy and optimal monetary policy has emerged (for example Quint and Rabanal, 2014; or Angelini, Neri and Panetta, 2012). The focus of this thesis on the interaction between fiscal and macroprudential policy is of great relevance, especially in the context of a monetary union. This is because it is worth analyzing the set of national policies that the authorities have at their disposal when their countries cannot set their own monetary policy to stabilize its

economy.

Optimal policy in Chapter 3 is the one that minimizes a specific loss function (composed of the volatility of certain variables in the model) that is of interest to the corresponding competent authority. To that aim, I analyze a scenario in which only the country that suffers the shock implements optimal macroprudential policy; a second scenario in which the country not responsible for the shock is the only one implementing macroprudential policy; and a third scenario in which optimal macroprudential policy is federally-implemented. Then I replicate this analysis for the case in which optimal macroprudential policy coordinates with optimal fiscal policy. Likewise, an assessment of the welfare gains or costs that each of the previous scenarios entails is performed. What the final part of the thesis shows is that, in case of financial shocks, the introduction of optimal macroprudential policies always implies welfare improvements. Instead, when the economy suffers a supply or demand shock the results in terms of welfare of implementing optimal macroprudential policy are not always positive.

At the end of this dissertation the overall conclusions for the whole research can be found.

Introducción (Spanish)

La política macroprudencial ha adquirido una enorme relevancia en las economías más avanzadas (los países emergentes ya estaban utilizándolos), sobretodo desde la severa recesión financiera de 2007 y su posterior alcance. Esta política consiste en una nueva herramienta económica que complementa a las políticas tradicionales garantizando la estabilidad del sistema financiero, el cual es clave para mantener una economía estable.

La manera más conveniente de implementar la política macroprudencial y los instrumentos macroprudenciales que deben utilizarse forma parte de un debate que todavía permanece abierto. A pesar de ello, la Junta Europea de Riesgo Sistémico (en inglés European Systemic Risk Board o ESRB) recomienda a las autoridades macroprudenciales que, para alcanzar el fin último de la política maccroprudencial de salvaguardia del sistema financiero en su totalidad, persigan unos objetivos intermedios dirigidos sus sistemas financieros nacionales (ESRB/2013/1). Los objetivos intermedios buscan mitigar el crecimiento del crédito y endeudamiento privado, prevenir el excesivo desajuste en los vencimientos y la iliquidez de mercado, limitar la concentración de exposiciones directas e indirectas, limitar el impacto sistémico de incentivos desalineados para reducir el riesgo moral y fortalecer las infraestructuras financieras. El cumplimiento de estos objetivos intermedios garantizaría un sistema financiero más resistente y disminuiría la acumulación de riesgos sistémicos.

La política monetaria también se ha orientado en algunas ocasiones al control del sector financiero, pero algunos estudios, como Lambertini, Mendicino y Punzi (2013), explican que no es la opción que trae la mayor estabilidad. Por un lado, la política

monetaria no es tan efectiva como la política macroprudencial en el cumplimiento de los objetivos anteriormente explicados. Por otro lado, no conviene descentrar a la política monetaria de su objetivo principal, la estabilidad de los precios. Por eso es necesario introducir la política macroprudencial como parte del conjunto de políticas económicas.

Merece la pena mencionar que la política macroprudencial se enfrenta a importantes retos principalmente porque la experiencia en su uso es muy limitada. Además, todavía quedan algunas preguntas e incógnitas relacionadas con la política macroprudencial que el tiempo se encargará de responder, entre otras, los efectos secundarios que estas medidas conlleven. Sin embargo, es indiscutible que su uso crece exponencialmente, y que la política macroprudencial se está convirtiendo en una pata esencial del conjunto de políticas económicas.

Esta tesis doctoral analiza el uso de la política macroprudencial a través de modelos de Equilibrio General Dinámico Estocástico (EGDE o DSGE por sus siglas en inglés) y pretende aportar un nuevo enfoque para su estudio complementando la literatura existente. En particular, mi instrumento macroprudencial, basado en Quint y Rabanal (2014), afecta a la oferta de préstamos de forma equivalente a los requerimientos de capital, requerimientos de reservas, ratios de liquidez o provisiones dinámicas de préstamos, implementados en el mundo real (Cerutti et al., 2015 o Lim et al., 2011).

La implementación de la política macroprudencial en mi modelo es contracíclica. Existe un gran número de estudios empíricos sobre la efectividad del las políticas macroprudenciales contracíclicas. Entre otros, Cerutti et al. (2015), descubren que la política macroprudencial mitiga significativamente el desarrollo del crédito, lo que implica estabilidad en el sistema financiero. Estos autores analizan el creciente uso de los instrumentos macroprudenciales, a lo largo del periodo 2000-2013. Los requerimientos de reservas están presentes en el 21% de la combinación total de instrumentos, utilizados a lo largo de los años analizados y por todo el conjunto de 119 países avanzados, en desarrollo y emergentes de su muestra; las provisiones de préstamos representan alrededor del 9% del conjunto total; y los requerimientos de

capital sobre el 2%. El análisis de regresión de países de Lim et al. (2011) sugiere que muchos de los instrumentos macroprudenciales usados con más frecuencia son efectivos reduciendo la prociclicalidad del crédito. Estos autores remarcan las ventajas de instrumentos macroprudenciales basados en reglas que son ajustados automáticamente para contrarrestar la ciclicalidad del crédito como "estabilizadores automáticos". Sin embargo, su análisis es sensible al tipo de perturbación al que hace frente el sector financiero. Algunos ejemplos de este tupo de medidas son las provisiones dinámicas y los amortiguadores de conservación de capital según Basilea III. Los autores también señalan que los países que introdujeron requerimientos de reservas redujeron la prociclicalidad del crédito y los instrumentos de provisiones dinámicas invirtieron la correlación entre el crecimiento del crédito y del PIB. En mi tesis, utilizo una herramienta macroprudencial basada en una regla que permite suavizar el ciclo y opera de manera equivalente a estos efectivos instrumentos macroprudenciales.

En esta tesis, el uso de la política macroprudencial persigue el fin último de lograr la estabilidad financiera y económica en una economía en la que una perturbación desvía a las variables económicas de su estado estacionario. El análisis principal de esta tesis se basa en el caso de una perturbación financiera que consiste en un aumento del riesgo de crédito en el sector privado que desestabiliza la economía, similar al de la Gran Recesión. La motivación para que la investigación gire en torno a esta perturbación financiera radica en el argumento de Christiano, Motto y Rostagno (2010), que encuentran que estas perturbaciones de riesgo de crédito son responsables de una gran parte de las fluctuaciones de los ciclos económicos.

La perturbación financiera genera un canal en el modelo estudiado en esta tesis que conecta negativamente la deuda privada y la deuda pública, contribuyendo a una mayor desestabilidad. Este canal de deuda privada-pública funciona de la siguiente forma. Tras una perturbación financiera, que aumenta el riesgo de crédito, el PIB se desploma. *Ceteris paribus*, esa caída del PIB reduce los ingresos públicos provenientes de la recaudación impositiva lo que lleva a un aumento de la deuda pública. Al mismo tiempo, la perturbación endurece las condiciones financieras al

sector privado, produciéndose un incremento del tipo de interés de los préstamos. Por ello, la oferta y la demanda de deuda privada disminuyen, lo cual implica una caída de la inversión privada y una mayor caída PIB. De esta forma, aparece una correlación negativa entre la deuda privada y la deuda pública, lo cual genera el canal previamente mencionado. Por lo tanto, el canal amplifica la caída del PIB tras este tipo de perturbación financiera. Como el origen de la desestabilización económica en el presente análisis reside en el canal de deuda privada-pública, en el caso de que se produzcan estas perturbaciones financieras, es necesario encontrar una forma de suavizarlo. Una forma posible de cancelar el canal consiste en incluir la política macroprudencial en el modelo. Por eso, mi tesis realiza un análisis detallado de la política macroprudencial, considerando las distintas formas de aplicarla, su interacción con otras políticas y los efectos de la política macroprudencial cuando otro tipo de perturbaciones golpean la economía.

La principal novedad de esta investigación radica en que gira en torno a la interacción de la política fiscal y la política macroprudencial. El motivo del interés por la combinación de políticas fiscal y macroprudencial en mi tesis es que, en el contexto de una unión monetaria, son las herramientas con las cuales pueden contar las autoridades nacionales para hacer frente a sus propias necesidades de estabilización. La interacción entre ambas políticas permite estabilizar al mismo tiempo la deuda pública y la deuda privada, y por consiguiente la economía global. Por lo tanto, la tesis se centra en cómo la política fiscal, encargada de estabilizar la deuda pública, es complementada con política macroprudencial, encargada de estabilizar la deuda privada. Este análisis adquiere especial relevancia en el contexto de una unión monetaria en la que la política monetaria no puede ser utilizada por las autoridades nacionales para apoyar a la política fiscal en su labor de estabilización de la economía.

Un análisis profundo de la política macroprudencial requiere la observación de una gran variedad de aspectos. En primer lugar, existe un amplio abanico de instrumentos macroprudenciales que pueden introducirse como herramientas de las autoridades correspondientes. La primera parte de la tesis se encarga de analizar este área concreta. Mediante un modelo DSGE para una economía cerrada, basado en

el desarrollado en Fernández-Villaverde (2010), realizo una comparación de cómo distintas implementaciones de política macroprudencial afectan a la economía tras una perturbación financiera consistente en un aumento del riesgo de crédito. El instrumento macroprudencial controla de la cantidad de préstamos que el sector bancario puede conceder al sector privado. La política macroprudencial se introduce bien como la obligatoriedad de los bancos de mantener en su balance, sin ser prestados, una parte de los fondos que reciben, o bien como la concesión a los mismos de prestar más fondos que la cantidad de depósitos que reciben. Como ya se ha mencionado anteriormente, en la economía real el instrumento equivalente es un requerimiento de reservas cuando la política macroprudencial es restrictiva, y una provisión directa de liquidez a los bancos si la política macroprudencial es flexibilizadora. Para flexibilizar o endurecer este instrumento macroprudencial, las autoridades macroprudenciales deben considerar una serie de indicadores financieros en función de los objetivos que persigan. Por tanto, el primer capítulo de esta tesis compara la implementación de dos medidas macroprudenciales, diferenciadas por el indicador financiero al que reaccionan. En línea con Quint y Rabanal (2014) una de las medidas responde a cambios en el crecimiento del crédito privado nominal y la otra estabiliza el ratio de la deuda privada sobre el PIB.

Además, esta parte de la tesis también incluye diferentes combinaciones de políticas fiscales y monetarias, basadas en Leeper, 1991, estableciendo dos escenarios susceptibles de análisis: uno de política fiscal activa y monetaria pasiva y otro de política fiscal pasiva y monetaria activa. Según Leeper, 1991, las políticas pasivas se encargan de estabilizar la deuda pública y equilibrar el presupuesto del Estado. En el análisis que esta tesis realiza y también siguiendo el enfoque de Leeper, 1991, la política monetaria activa estabiliza la inflación y la política fiscal activa responde a fluctuaciones en el PIB en lugar de fluctuaciones en el endeudamiento del gobierno. Estos dos escenarios arrojan a su vez distintos resultados para cada una de las dos implementaciones de política macroprudencial consideradas en el primer capítulo de la tesis. Existen también otros estudios, como la de Gomes y Seoane (2018), que también incluyen esta categorización de políticas fiscales y monetarias activas y pasivas. Sin embargo, esta tesis combina la política macroprudencial con estos

escenarios de política activa y pasiva y compara los efectos de la perturbación en diferentes casos con o sin política macroprudencial.

Los resultados obtenidos tras este primer análisis sugieren que las políticas económicas tradicionales (fiscal y monetaria) no son capaces de anular el canal deuda privada-pública. Por tanto, la política fiscal y monetaria por si mismas no logran estabilizar la economía, independientemente de cómo se diseñe la combinación de políticas fiscal/monetaria activa/pasiva. Sin embargo, el uso de políticas macroprudenciales siempre cancela el canal responsable de la desestabilización en respuesta a una perturbación del riesgo de crédito. Al anular el canal, la política macroprudencial contribuye bien a la estabilidad financiera (reaccionando a cambios en el ratio de deuda privada sobre PIB) o bien a la estabilidad macroeconómica (reaccionando a cambios en el crecimiento del crédito privado nominal), independientemente de la combinación de políticas fiscal-monetaria activa/pasiva.

En segundo lugar, otra parte de la literatura que analiza la política macroprudencial, se ha centrado en sus efectos en una unión monetaria (ver por ejemplo Quint y Rabanal, 2014; Brzoza-Brzezina, Kolasa y Makarski, 2013; o Rubio, 2014). Esto alienta el análisis de la segunda parte de la tesis en la que se implementa la política macroprudencial en un modelo DSGE de dos países para una unión monetaria. El modelo incluye un mercado de bienes internacional y un mercado financiero incompleto internacional a través de los cuales se conectan ambos países. En esta ocasión, el escenario de política fiscal y monetaria considerado consiste en la combinación de políticas fiscales pasivas (que estabilizan la deuda pública, en línea con Leeper, 1991) y una política monetaria activa (que estabiliza la inflación, en línea con Leeper, 1991). Según Leith y Wren-Lewis (2006), un requisito para que exista equilibrio en una unión monetaria es que la política monetaria activa se combine con políticas fiscales pasivas.

En esta parte de la tesis, el anteriormente mencionado escenario de política monetaria y fiscal se combina con distintas implementaciones de la política macroprudencial. Estas implementaciones siempre consisten en controlar los fondos que los bancos pueden prestar a través de un instrumento que responde al crecimiento del

crédito nominal. El análisis compara los efectos de la política macroprudencial aplicada a nivel nacional con los efectos de la política macroprudencial aplicada a nivel de la unión, de manera similar a Dehmej y Gambacorta (2017).

El análisis del segundo capítulo, considera que una perturbación financiera que implica el aumento del riesgo de crédito se origina en uno de los dos países que componen la unión monetaria. El otro país es afectado indirectamente por la perturbación. De nuevo aparece el canal de deuda privada-pública que desestabiliza la economía, pero además existe un canal adicional en este modelo: el canal de economía abierta. Este canal funciona debido al efecto en el cambio de los gastos (ver, por ejemplo, Engel, 2003; Galí y Monacelli, 2003; o Corsetti, 2007). El resultado más relevante de este capítulo es que cuando se implementa una política macroprudencial nacional, es posible alcanzar la estabilidad financiera y macroeconómica en ambos países, gracias a la anulación del canal de deuda privada-publica. Sin embargo, cuando la política macroprudencial se implementa a nivel de la unión, el país responsable del shock consigue una mayor estabilidad, debido al canal de economía abierta, mientras que el país que no sufre directamente el shock se desestabiliza.

Los escenarios explicados en el Capítulo 2, para una unión monetaria, asumen que los países se ponen de acuerdo para implementar la política macroprudencial pues, incluso cuando es a nivel nacional, cada uno de ellos estabiliza sus propias variables financieras, pero siguiendo la misma regla macroprudencial. Sin embargo, como explican Rubio y Carrasco-Gallego (2016), podría darse la situación de que los países de la unión no se coordinen en la implementación de la política macroprudencial. Por ello, en mi análisis, considero el caso en el que alguno de los dos países no implementa la política macroprudencial mientras que el otro sí lo hace. Además, esta segunda parte de mi investigación aporta también un análisis de robustez que estudia situaciones en las que diferentes perturbaciones golpean a uno de los países y cómo las economías reaccionan ante las distintas implementaciones de política macroprudencial descritas.

Los dos primeros capítulos que componen esta tesis comparan el uso de distintos instrumentos macroprudenciales y formas de implementar la política macropruden-

cial y su combinación con las políticas económicas tradicionales. Ambos análisis son puramente positivos, no normativos, por lo que no se postulan acerca de cuál es la mejor opción a la hora de decidir cómo aplicar la política macroprudencial. Por eso, la última parte de la tesis consiste en un análisis normativo, de política óptima, que estudia la conveniencia de implementar uno u otro escenario de política macroprudencial en función de los objetivos que se persigan.

La principal novedad del tercer capítulo es que analiza la interacción entre la política macroprudencial óptima y la política fiscal óptima dentro de una unión monetaria. La mayor parte de la literatura que realiza análisis similares para uniones monetarias se centra en cómo se coordinan las políticas fiscales y monetarias óptimas (algunos ejemplos son Galí y Monacelli, 2005; o Ferrero, 2005). Sin embargo, en los últimos años ha aflorado un creciente interés por la interacción entre la política macroprudencial óptima y la política monetaria óptima (por ejemplo, Quint y Rabanal, 2014; o Angelini, Neri y Panetta, 2012). El foco de la presente tesis en la interacción entre la política fiscal y la macroprudencial tiene una enorme relevancia, especialmente en el contexto de una unión monetaria. Esto se debe a que conviene analizar las políticas nacionales que tienen a su disposición las autoridades de los países que no pueden contar con una política monetaria propia para estabilizar su economía.

La política óptima en el Capítulo 3 es la que minimiza una determinada función de pérdidas (compuesta por la volatilidad de una serie de variables del modelo) que interesa a la autoridad competente en cuestión. Para ello, analizo un escenario en el cual solo el país que sufre la perturbación implementa la política macroprudencial; un segundo escenario en el cual el país que no es responsable de la perturbación es el único que implementa la política macroprudencial; y un tercer escenario en el cual la política macroprudencial óptima se implementa de manera federal. A continuación, replico este análisis para el caso en el que la política macroprudencial óptima se coordina con la política fiscal óptima. Asimismo, se realiza una evaluación de los costes o beneficios en términos de bienestar que conllevan los anteriores escenarios. Lo que muestra el final de la tesis es que, en el caso de perturbaciones financieras, la introducción de políticas macroprudenciales óptimas siempre implica

mejoras de bienestar. En cambio, cuando la economía sufre una perturbación de oferta o de demanda los resultados en términos de bienestar de implementar políticas macroprudenciales óptimas no siempre son positivos.

Al final de la tesis se presentan las conclusiones generales de toda la investigación.

Chapter 1

Financial frictions and stabilization policies

1.1 Introduction

After the financial crisis of 2007, in some countries such as the U.S. and Spain, public and private debt have moved in opposite directions, as opposed to pre-2007 evidence. Private deleverage and public debt build-up may affect the recovery path of countries after a recession.

This chapter studies how this link between private and public debt may amplify the business cycle and which policy tools are required to stabilize the economy.

Table 1.1 presents the correlation between private and public debt (B-D), public debt and output (D-Y) and government spending and output (G-Y), respectively, in the U.S. and Spain for period 1960-2017 (top panel) and the subperiod 2007-2017 (bottom panel).[1] It shows that, for the whole sample, the correlation between private and public debt is positive, with government spending being procyclical in both

Chapter 1 is a joint work with Beatriz de Blas Pérez (UAM).

[1] In Table 1, private debt (B) includes private debt held by households. Subtracting households' private debt from the series implies that the correlation between B and D for the subperiod 2007-2017 is -0.511 in the case of Spain and -0.275 in the case of the US. These values, though lower than those presented in the table, still certify the negative correlation between these two variables after 2007.

countries. However, since the onset of the recent financial crisis and until 2017, both countries present a negative correlation between their levels of private and public debt, with government spending being countercyclical in the US and procyclical in Spain. That is, since 1960, recession times have witnessed a build up of both public and private debt, and vice versa. However, this pattern changes during the Great Recession, with public and private debt moving in opposite directions, independently of the cyclicality of government spending. In part, this may be the result of the deleveraging process undertaken by the private sector in economies seriously affected by the crisis. In some countries, governments feeling less constrained, enjoyed greater room for cycle stabilization at the cost of more public leverage, for example in the U.S. But at the same time, we observe countries in which governments were forced to retrench too. In these countries downturns were amplified (GDP volatility increases by almost 40% in Spain during 2007-2017 compared to the sample 1960-2017). This seems to suggest a non-obvious role of fiscal policy in economic stability. On the one hand, fiscal policy could have accentuated the recession in countries such as Spain; on the other hand, a different fiscal strategy may have not sufficed to stabilize the economy in countries such as the US.

Table 1.1: Contemporaneous correlations among main debt and output aggregates, Spain and U.S.

Period 1960-2017			
	$\rho(B,D)$	$\rho(D,Y)$	$\rho(G,Y)$
Spain	0.493	-0.458	0.577
US	0.814	-0.147	0.173
Subperiod 2007-2017			
	$\rho(B,D)$	$\rho(D,Y)$	$\rho(G,Y)$
Spain	-0.556	-0.820	0.672
US	-0.913	-0.333	-0.458

Note: B denotes real private debt-to-real GDP ratio; D is real public debt-to-real GDP ratio; Y represents real GDP, and G is real government consumption. Both real GDP, Y, and real public consumption, G, have been detrended using the Hodrick Prescott filter. To evaluate real private and public debt we use their ratio over GDP. Source: See Appendix A.

Understanding which channel can rationalize this negative correlation and what are the consequences for the economy is one of the objectives of this chapter. To this end, we setup a new Keynesian model with financial frictions which accounts for the

negative comovement between public and private debt in an economy where fiscal policy aims at stabilizing public debt via a fiscal rule. The model predicts that in the event of a recession originated after a credit risk shock, output falls. The downturn expands to the rest of the economy; private debt goes down enhancing the fall in investment (financial accelerator) and amplifying the recession. Revenues from tax collection go down, and other things equal, this increases public debt. As a result, during a recession originated in the private sector, public and private debt move in opposite directions, what we call the *private-public debt channel*. This negative feedback between private and public debt acts as an amplifier of the shock on output.

In this framework, we assess the ability of standard monetary-fiscal policy mixes to cancel the private-public debt channel. Hence, we compare different scenarios depending on monetary and fiscal policies being active or passive, in line with the seminal work in Leeper (1991). We find that standard combinations of active/passive policies do not achieve stabilization of both public and private debt in response to credit risk shocks. Moreover, these alternative scenarios do not alter the response of the financial accelerator, as we model it.

In light of these results, our second objective is to analyze additional tools to mitigate this private-public debt channel, and therefore to smooth business cycle fluctuations. We use macroprudential policy to focus on financially-related variables, and let fiscal policy focus on public debt stabilization.[2]

Following Quint and Rabanal (2014) we introduce macroprudential policy as an instrument affecting the supply of credit in an equivalent way to capital requirements, reserve requirements, liquidity ratios or loan-loss provisions. Cerutti et al. (2015) and Lim et al. (2011), among others, report evidence on the effectiveness of these macroprudential measures in the real-world economy associating them with reductions in the procyclicality of credit and leverage. In particular, we compare the performance of a macroprudential tool which reacts to private credit growth, with

[2]Most previous literature has focused on how macroprudential policies interplay with monetary policies. Here, we add fiscal policy to the analysis of the interaction across policies.

an alternative tool which responds to the credit-to-GDP ratio. With macroprudential policies in place, we find that the private-public debt channel is partially or completely offset after a credit risk shock. Our results are sensitive to the monetary-fiscal policy mix considered. That is, the effectiveness of macroprudential measures in terms of output and private debt stabilization depends on both the policy mix and the way macroprudential policy is designed.[3]

For all the scenarios considered, the macroprudential tool which stabilizes private debt the most after a credit risk shock is the one that reacts to the credit-to-GDP ratio, but this is at the cost of more output instability. In turn, the macroprudential tool bringing more overall economic stability is the one that reacts to nominal credit growth. The results are robust to alternative parameterizations of macroprudential policy and relative weights of output and target stabilization in the policymaker's preferences. Therefore, we conclude that macroprudential policies provide additional tools to eliminate or, at least, reduce the amplification of business cycles originating after risk shocks in the private sector.

Finally, we also investigate the performance of macroprudential policies in response to technology and government spending shocks. In the event of these shocks, the monetary-fiscal policy mix does affect the private-public debt channel. Introducing macroprudential policies helps reduce overall macroeconomic volatility mostly under a active monetary policy and a passive fiscal policy mix, at the cost of private debt volatility.

Chapter 1 is organized as follows. In Section 1.2, we review the related literature. Section 1.3 describes the economy model and macroprudential policies. Section 1.4 then presents the equilibrium and market clearing conditions. Section 1.5 reports the calibration of the model. In Section 1.6, we analyze the effects of a credit shock on the main economic variables. In Section 1.7, we explain the how other shocks (technology and government spending) affect our economy model. Section 1.8 concludes.

[3] Quint and Rabanal (2014), in an open economy framework, also find that the stabilization effects of macroprudential policies are not symmetric and depend on the fiscal-monetary policy mix implemented.

1.2 Related literature

This chapter builds on Fernández-Villaverde (2010) and Gomes and Seoane (2018) who use a new Keynesian framework with financial frictions à-la-Bernanke, Gertler and Gilchrist (1999).

Fernández-Villaverde (2010) studies the effects of fiscal policy on output focusing on the use of proportional taxes and a fiscal rule in the presence of financial frictions. In his model, government spending reacts to changes in the lagged public debt-to-GDP ratio. He finds that, when seeking to stabilize output, changes in government spending seem to be more effective than changes in taxes. We build on his model and focus mainly on risk shocks as a key element in the propagation of the recent financial crisis (Christiano et al., 2010). Fernández-Villaverde focuses on the response of output to different fiscal shocks. Going one step further, our analysis emphasizes the role of automatic stabilizers in shaping the response of private and public leverage. We obtain that the link between these two variables may amplify the effects of financial shocks on output.

We are not the first to analyze the relationship between public and private debt imbalances (among others, Corsetti, Kuester, Meier and Müller, 2013). However, to our knowledge, we are the first to assess this negative correlation between public and private debt (present in the data) in a general equilibrium model and address its effects in the economy.

Our work is also closely related to Gomes and Seoane (2018). These authors argue that different combinations of active/passive monetary and fiscal policies are able to explain the distinct recovery paths across countries (in their paper, the US and Euro Area), after the Great Recession. We differ from their model in that we consider proportional instead of lump-sum taxes. This feature turns out to be crucial in our analysis, since the presence of automatic stabilizers is key for the propagation of financial shocks to the public sector and for the transmission of macroprudential measures from the private sector to the rest of the economy. We compare the effects of the private-public debt channel under an active fiscal policy scenario (what would

have been the US case) to the effects under a passive fiscal policy scenario (what could be referred to as the case of Spain).[4] In our model, the traditional monetary-fiscal policy mix is not enough to stabilize the economy after a credit risk shock. The fact that monetary policy does not react to financial variables calls for additional tools to support and coordinate with fiscal policy in order to enhance economic stability.

We consider an additional instrument for macroeconomic stabilization: macroprudential policies. There is an extensive literature analyzing the interaction between monetary and macroprudential policies.[5] The former are aimed at price stability, while the latter focus on financial stability. In line with our framework, Rubio and Carrasco-Gallego (2014) implement a DSGE model which combines monetary and macroprudential instruments to evaluate their effects on business cycles, welfare and financial stability. The authors find that the restriction of credit during booms contributes to business cycle stabilization and improves welfare, while it might enter in conflict with monetary policy. However, the stability of the system is improved when both policies operate jointly. Quint and Rabanal (2014) study the effects of a negative risk shock in a two-country currency union. These authors observe that monetary policy by itself cannot contain the accelerator effects that the shock has on the economy. In their model, a macroprudential policy constraining either the ratio of credit to GDP or nominal credit growth can attain stability. We incorporate their macroprudential tools to our closed-economy analysis and study the interactions with both monetary and fiscal policies.

Despite the extensive literature on the interplay between macroprudential and monetary policies, there is not much about how macroprudential and fiscal policies

[4] We do not consider the case of the Euro Area as in Gomes and Seoane (2018) because even though it is easy to characterize monetary policy at the union level, it is more difficult to study a common fiscal policy in this scenario. That is, when analyzing the Euro Area, imposing an active/passive fiscal policy may not be representative of the environment it pretends to study. In our work, we focus on the effects of the policy mix on the main variables of the financial sector of an individual closed economy. See Chapter 2 for the analysis of the policy mix in a currency union.

[5] The literature has grown considerably in the recent years. Just to cite some papers, see Gerlach et al. (2009), Angelini et al. (2012), de Paoli and Paustian (2013), or Gelain and Ilbas (2017).

interact. This chapter tries to fill in this gap. Fiscal policy becomes relevant in our analysis due to the role of automatic stabilizers. To get some intuition, in the presence of the *private-public debt channel*, a falling private debt which depresses the economy may exacerbate the fall in tax collection, leading to further adjustments in government expenditure and higher public debt. The use of policies directed to stabilize private debt may reduce this amplification channel by letting fiscal policy focus on public finances stabilization. Claessens (2014), in his review of macroprudential and monetary interactions, highlights the importance of coordinating the use of macroprudential instruments with other policy interventions, including fiscal and microprudential policy actions. Regarding fiscal policy, Claessens (2014) argues that some tax policies can contribute to systemic risk by encouraging private leverage (for instance, when interest payments are tax deductable) and therefore macroprudential authorities need to coordinate with fiscal authorities. The present chapter sheds new light on policy mix coordination: we show that standard monetary and fiscal policy combinations are not enough to jointly stabilize both public and private debt in response to risk shocks. Therefore, we propose the inclusion of macroprudential instruments as part of the policy mix.

1.3 The model

Our model economy follows closely Fernández-Villaverde (2010). The economy is composed of households, intermediate good producers, final good producers, entrepreneurs, capital goods producers, financial intermediaries and a government setting fiscal, monetary and, when considered, macroprudential policies. We quickly present the model and focus on the introduction of macroprudential policies.

1.3.1 Households

There is a continuum of households with infinite life. The representative household maximizes his utility function, choosing consumption, c_t; time devoted to work, l_t; and financial assets composed of deposits, a_t, and government bonds, d_t, both in

positive amounts. The individual's utility function is given by

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\log\left(c_t - h c_{t-1}\right) - \psi \frac{l_t^{1+\vartheta}}{1+\vartheta} \right], \tag{1.1}$$

where $\beta \in (0,1)$ is the discount factor; $h \geq 0$ reflects the degree of habit persistence; $\psi > 0$ denotes the magnitude of the labor disutility relative to consumption utility; and $\vartheta > 0$ is the inverse of the Frisch elasticity of labor supply.

The household makes decisions subject to the following budget constraint:

$$\begin{aligned}(1+\tau_c)\, c_t + \frac{a_t}{p_t} + \frac{d_t}{p_t} = (1-\tau_l)\, w_t l_t + \left[1 + (1-\tau_R)\left(R_{t-1} - 1\right)\right] \frac{a_{t-1}}{p_t} \\ + R^d_{t-1} \frac{d_{t-1}}{p_t} + T_t + F_t + tre_t. \end{aligned} \tag{1.2}$$

The left hand side of equation (3.3) represents the household's expenditures in real terms. The right hand side describes the sources of income to the household: labor income, $w_t l_t$, where w_t is the real wage; interests on last period investment on deposits, $R_{t-1} a_{t-1}$ and on public assets, $R^d_{t-1} d_{t-1}$; and net transfers from the government, T_t. The model includes proportional taxes on real consumption, τ_c, on labor income, τ_l and on net returns on deposits, τ_R.[6] Dividends are paid by firms to households, F_t. Finally, households also receive a net transfer from entrepreneurs, tre_t, defined as follows:

$$tre_t = (1-\gamma^e)\, n_t - w^e. \tag{1.3}$$

As will be explained in detail below, γ^e is the survival rate of entrepreneurs from one period to the next one. The net wealth of exiting entrepreneurs, $(1-\gamma^e)\, n_t$, is paid back to households, who in turn transfer w^e to incoming entrepreneurs. This consititutes the initial real net wealth of the new entrepreneurs.

The first order conditions obtained from the representative household's problem are

[6] Returns on sovereign debt are not taxed because, as Fernández-Villaverde (2010) says, otherwise the government would have to pay a higher interest rate on public debt to compensate for the lower net return that households would receive due to the tax, thus the effect would be the same.

$$\frac{1}{c_t - hc_{t-1}} - \beta E_t \frac{h}{c_{t+1} - hc_t} = \lambda_t \left(1 + \tau_c\right), \tag{1.4}$$

$$\lambda_t = \beta E_t \lambda_{t+1} \frac{\left[1 + \left(1 - \tau_R\right)\left(R_t - 1\right)\right]}{\Pi_{t+1}}, \tag{1.5}$$

$$\lambda_t = \beta E_t \lambda_{t+1} \frac{R_t^d}{\Pi_{t+1}}, \tag{1.6}$$

$$\psi l_t^{\vartheta} = \left(1 - \tau_l\right) w_t \lambda_t, \tag{1.7}$$

where λ_t is the Lagrange multiplier which represents the marginal value of wealth of households; and $\Pi_t = \frac{p_t}{p_{t-1}}$ denotes the gross inflation rate.

1.3.2 Intermediate goods producers

These agents produce differentiated goods which are then sold in a monopolistically competitive market to final good producers, who use them in their production process. Each intermediate good producer, i, chooses labor l_{it} and capital k_{it-1} as factors of production and creates output y_{it} through the following constant returns to scale Cobb-Douglas production function:

$$y_{it} = e^{z_t} k_{it-1}^{\alpha} l_{it}^{1-\alpha}, \tag{1.8}$$

where $0 \leq \alpha \leq 1$ is the capital share of the intermediate production function.

Technology follows an exogenous AR(1) process $z_t = \rho_z z_{t-1} + \sigma_z \varepsilon_{z,t}$, where $0 < \rho_z < 1$, $\varepsilon_{z,t} \backsim N(0,1)$, and σ_z is the volatility of the technology shock.

Labor is hired from households in exchange for real wages w_t. Capital is rented from entrepreneurs at a real interest rate r_t. Cost minimization implies

$$k_{it-1} = \frac{\alpha}{1 - \alpha} \frac{w_t}{r_t} l_{it}. \tag{1.9}$$

These firms reset their prices through a Calvo pricing mechanism. Each period a fraction $1-\theta$ of producers can change their price, while a fraction θ has to keep the previous period's price which is then indexed to past inflation.

Firms resetting their prices in period t maximize the following expression:[7]

$$E_t \sum_{\tau=0}^{\infty} (\beta\theta)^{\tau} \frac{\lambda_{t+\tau}}{\lambda_t} \left[\left(\prod_{s=1}^{\tau} \frac{\Pi_{t+s-1}^{\chi}}{\Pi_{t+s}} \frac{p_{it}}{p_t} - mc_{t+\tau} \right) y_{it+\tau} \right], \tag{1.10}$$

subject to the sequence of demand functions

$$y_{it+\tau} = \left(\prod_{s=1}^{\tau} \frac{\Pi_{t+s-1}^{\chi}}{\Pi_{t+s}} \frac{p_{it}}{p_t} \right)^{-\varepsilon} y_{t+\tau}. \tag{1.11}$$

In the expressions above, $\frac{\lambda_{t+\tau}}{\lambda_t}$ is the stochastic discount factor, taken as given by the monopolistically competitive firm; mc_t denotes the marginal cost of the intermediate good producer; p_{it} is the price set in period t by firm i; p_t is the aggregate price level; $\chi \in [0,1]$ represents the degree of price indexation; $y_{it+\tau}$ denotes output in period $t+\tau$ for a firm that last reset its price in period t; $y_{t+\tau}$ is the aggregate level of output in time $t+\tau$; and $\varepsilon \geq 1$ is the elasticity of substitution across goods. Let the reset price relative to the price level be $\Pi_t^* = \frac{p_t^*}{p_t}$.

The first order conditions for these intermediate firms are:[8]

$$\frac{k_{t-1}}{l_t} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t}, \tag{1.12}$$

$$mc_t = \left(\frac{1}{1-\alpha} \right)^{1-\alpha} \left(\frac{1}{\alpha} \right)^{\alpha} \frac{w_t^{1-\alpha} r_t^{\alpha}}{e^{z_t}}, \tag{1.13}$$

[7] The expression represents the discounted sum of the difference between the optimizing firm's revenues and its marginal cost, that is, the discounted profits for a firm that last reset its price in period t.

[8] Since all intermediate good producers face the same prices and because of market clearing, subscript i can be removed from the previous expression, meaning that all the monopolistically competitive producers choose the same ratio for the production factors they use, $\frac{k_{it-1}}{l_{it}}$, so that capital and labor will be expressed in aggregate levels.

$$\varepsilon f_t^1 = (\varepsilon - 1) f_t^2, \tag{1.14}$$

where

$$f_t^1 = \lambda_t m c_t y_t + \beta\theta E_t \left(\frac{\Pi_t^{\chi}}{\Pi_{t+1}} \right)^{-\varepsilon} f_{t+1}^1, \tag{1.15}$$

and

$$f_t^2 = \lambda_t \Pi_t^* y_t + \beta\theta E_t \left(\frac{\Pi_t^{\chi}}{\Pi_{t+1}} \right)^{1-\varepsilon} f_{t+1}^2 \left(\frac{\Pi_t^*}{\Pi_{t+1}^*} \right), \tag{1.16}$$

where, following Fernández Villaverde (2010), f_t^1 and f_t^2 are two auxiliary variables.

Finally, the aggregate price index can be expressed as follows:

$$1 = \theta \left(\frac{\Pi_{t-1}^{\chi}}{\Pi_t} \right)^{1-\varepsilon} + (1-\theta) \Pi_t^{*(1-\varepsilon)}. \tag{1.17}$$

1.3.3 Final goods producers

Final goods producers buy intermediate goods from intermediate goods producers and combine them to obtain the homogeneous final good according to the following Dixit-Stiglitz technology function:

$$y_t = \left(\int_0^1 y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{1.18}$$

where y_t is the aggregate output and $\varepsilon \geq 1$ is the elasticity of substitution across goods. The final good is sold to consumers in a perfectly competitive market. These firms maximize profits taking as given both the price of the intermediate good, p_{it}, and the price of the final good, p_t. The price level is given by

$$p_t = \left(\int_0^1 p_{it}^{1-\varepsilon} di \right)^{\frac{1}{1-\varepsilon}}. \tag{1.19}$$

1.3.4 Capital goods producers

These agents operate in a perfectly competitive market and create new capital, x_{t+1}, using investment, i_t, and installed capital, x_t, via the following production function:

$$x_{t+1} = x_t + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t, \tag{1.20}$$

where $S\left[\frac{i_t}{i_{t-1}}\right]$ denotes adjustment costs, such that $S'[\cdot] > 0; S''[\cdot] > 0; S[1] = 0;$ and $S'[1] = 0$.

Installed capital is previously purchased from entrepreneurs. Let q_t denote the relative price of capital, then discounted profits are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[q_t \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t - i_t\right]. \tag{1.21}$$

Market clearing implies that $x_t = (1-\delta)\, k_{t-1}$, where $\delta \in [0,1]$ is the capital depreciation rate. The first order condition is the following:

$$q_t \left(1 - S\left[\frac{i_t}{i_{t-1}}\right] - S'\left[\frac{i_t}{i_{t-1}}\right] \frac{i_t}{i_{t-1}}\right) + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} S'\left[\frac{i_{t+1}}{i_t}\right] \left[\frac{i_{t+1}}{i_t}\right]^2 = 1. \tag{1.22}$$

The law of motion of capital is given by

$$k_t = (1-\delta) k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t. \tag{1.23}$$

1.3.5 Entrepreneurs

Entrepreneurs are in charge of transforming installed capital, x_t, into inputs for use by intermediate goods producers, k_{t-1}. Each period, entrepreneurs buy new capital, k_t, from capital goods producers at a price q_t, to undertake their investment.

Entrepreneurs use both internal and external funds for the purchase of the newly installed capital, $q_t k_t$. Internal funds are composed of the end-of-period net worth (or equity of the entrepreneurs), n_t; while external funds consist of loans borrowed

from financial intermediaries, b_t. Therefore, the amount they borrow is given by[9]

$$\frac{b_t}{p_t} = q_t k_t - n_t. \tag{1.24}$$

Their technology is affected by an idiosyncratic shock, ω_{t+1}, which is lognormally distributed with cumulative distribution $F(\omega, \sigma_{\omega,t})$ with parameters $\mu_{\omega,t}$ and $\sigma_{\omega,t}$. We assume that $E_t\omega_{t+1} = 1$ for all t. The dispersion, $\sigma_{\omega,t}$, represents the credit risk of our model[10] and is assumed to follow:[11]

$$\widehat{\sigma}_{\omega,t} = \rho_{\sigma_\omega}\widehat{\sigma}_{\omega,t-1} + \eta_{\sigma_\omega}\varepsilon_{\sigma_\omega,t}, \tag{1.25}$$

where $\rho_{\sigma_\omega} \in [0,1]$ is the persistence coefficient, $\varepsilon_{\sigma_\omega,t} \backsim N(0,1)$, and η_{σ_ω} is the volatility of the shock. The shock, $\varepsilon_{\sigma_\omega,t}$, is revealed at the end of the period, just before the investment decisions for $t+1$ are taken.

Entrepreneurs rent their output to intermediate goods producers at a price r_{t+1} per unit of capital rented. We can define the ex-post average return of the entrepreneur per unit of investment between t and $t+1$, R^k_{t+1}, as

$$R^k_{t+1} = \Pi_{t+1}\frac{r_{t+1} + q_{t+1}(1-\delta)}{q_t}. \tag{1.26}$$

where $q_{t+1}(1-\delta)$ is the cost that the capital goods producer assumes for the repurchase of the old non-depreciated capital, paid to the entrepreneur at the end of the period.

The realization of ω_{t+1} is private information to entrepreneurs, and the contract with financial intermediaries is signed before it is known. This private information leads to a possible moral hazard problem that is solved via a standard debt contract. As in Bernanke, Gertler and Gilchrist (1999), we consider a costly state verification (CSV)

[9] Notice that this expression means the contract is set in nominal terms what implies that entrepreneurs' networth may be affected by the debt deflation channel.

[10] This credit risk may arise from household overborrowing or from risk-taking in financial markets.

[11] We use the notation $\widehat{x}_t$ to refer to the log-linearized version of variable x_t and $\overline{x}$ for the steady state value of the same variable.

problem: entrepreneurs observe their outcome for free, but financial intermediaries need to pay a cost, μ, proportional to the gross payoff of the entrepreneur's capital.

The standard debt contract specifies a state-contingent non-default repayment, R^l_{t+1}, (dependent on the ex-post realization of R^k_{t+1}) that the entrepreneur promises to pay to the financial intermediary in case of success of the investment project, that is, as long as the return is enough to meet the payment obligations with the financial intermediary. Otherwise the entrepreneur will default.

At the moment of the debt contract agreement there is aggregate uncertainty because R^k_{t+1} is not known yet. Once the entrepreneur has decided on the amount of capital to purchase, $q_t k_t$, and therefore the amount of external funds it needs, the entrepreneur and the financial intermediary agree to sign a one period contract given the ex-ante values of $q_t k_t$ and $\frac{b_t}{p_t}$. The threshold value of the idiosyncratic shock, ϖ_{t+1}, below which the entrepreneur defaults, is given by

$$R^l_{t+1} b_t = \varpi_{t+1} R^k_{t+1} p_t q_t k_t. \tag{1.27}$$

Summarizing, after the idiosyncratic shock is realized there are two possible scenarios:

- if $\omega_{t+1} > \varpi_{t+1}$ the financial intermediary will get $R^l_{t+1} b_t$ and the entrepreneur will keep the difference between his revenue and the interest payment on the loan, $\omega_{t+1} R^k_{t+1} p_t q_t k_t - R^l_{t+1} b_t$;
- if $\omega_{t+1} < \varpi_{t+1}$ the entrepreneur defaults and gets nothing while the financial intermediary gets $(1-\mu)\,\omega_{t+1} R^k_{t+1} p_t q_t k_t$, where $\mu \omega_{t+1} R^k_{t+1} p_t q_t k_t$ is the cost of monitoring.

If the entrepreneur defaults, it gets nothing. The financial intermediary takes the remaining fraction $(1-\mu)$ of the entrepreneur's return after paying bankruptcy procedures (a fraction μ). Hence, the CSV problem is designed to ensure that whenever the entrepreneur has generated enough revenue to pay its obligations, it

has an incentive to do so and to report truthfully. This is what Freixas and Rochet (2008) call the revelation mechanism.

The debt contract also establishes the return R_{t+1}^l the financial intermediary gets from the entrepreneur, arising from the zero profit condition

$$\left[1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] R_{t+1}^l b_t + (1-\mu) \int_0^{\varpi_{t+1}} \omega dF\left(\omega, \sigma_{\omega,t}\right) R_{t+1}^k p_t q_t k_t = R_t a_t. \quad (1.28)$$

Equation (1.28) shows that expected revenues obtained from lending activities must equal the cost of funds the financial intermediary has to pay back to households.

Following Fernández-Villaverde (2010), the problem of the entrepreneur is to choose both the leverage ratio and the schedule for ϖ_{t+1} by maximizing its expected net worth

$$\max_{\frac{\frac{b_t}{p_t}}{n_t}, \varpi_{t+1}} \frac{R_{t+1}^k}{R_t} \left[1 - \Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] \left(1 + \frac{\frac{b_t}{p_t}}{n_t}\right), \quad (1.29)$$

subject to the zero profit condition of the financial intermediary,

$$\left[\frac{R_{t+1}^k}{R_t} \left[\Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right) - \mu G\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] \left(1 + \frac{\frac{a_t}{p_t}}{n_t}\right) - \frac{\frac{a_t}{p_t}}{n_t}\right], \quad (1.30)$$

and given that in equilibrium $a_t = b_t$. In the equations above, $F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)$ denotes the probability of default and

$$G\left(\varpi_{t+1}, \sigma_{\omega,t}\right) = \int_0^{\varpi_{t+1}} \omega dF\left(\omega, \sigma_{\omega,t}\right). \quad (1.31)$$

Function $\Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right)$ stands for the share of entrepreneurial earnings accrued to the financial intermediary

$$\Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right) = \varpi_{t+1}\left[1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] + G\left(\varpi_{t+1}, \sigma_{\omega,t}\right). \quad (1.32)$$

The first order conditions are given by

$$\begin{aligned} & E_t \frac{R^k_{t+1}}{R_t} \left[1 - \Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] \\ +\xi_t & \left\{ \frac{R^k_{t+1}}{R_t} \left[\Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right) - \mu G\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] - 1 \right\} = 0, \end{aligned} \tag{1.33}$$

and

$$-\Gamma_\omega\left(\varpi_{t+1}, \sigma_{\omega,t}\right) + \xi_t \left[\Gamma_\omega\left(\varpi_{t+1}, \sigma_{\omega,t}\right) - \mu G\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] = 0, \tag{1.34}$$

where ξ_t is the Lagrangian multiplier.

After some algebra, we get

$$q_t k_t = \left[\frac{\xi_t}{E_t \frac{R^k_{t+1}}{R_t} \left[1 - \Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right]} \right] n_t. \tag{1.35}$$

where $q_t k_t$ are purchases of capital, as explained before, and where $\frac{R^k_{t+1}}{R_t}$ is the external finance premium, inversely related to the net wealth of the entrepreneur. Everything else equal, a rise in the external finance premium, $efp = \frac{R^k_{t+1}}{R_t}$, that initially reduces the expected probability of default, makes the entrepreneur take on more debt. This generates a decrease in net worth relative to external funds and therefore ends up increasing the expected probability of default.

As mentioned in the description of the household, at the end of every period a fraction γ^e of entrepreneurs survives while the rest die.[12] The net wealth of the exiting entrepreneurs, $\left(1 - \gamma^e\right) n_t$, is paid back to households. The new entrepreneurs replacing exiting ones enter the economy with initial net worth tre_t given by equation (1.3).

The average net wealth (equal to the wealth of the entrepreneur since the leverage

[12] Capital demand and capital return by entrepreneurs depend on the evolution of their net worth. And at the same time, entrepreneurs' net worth (equity) depends on their earnings net of interest payments to financial intermediaries. Therefore it is necessary to assume that entrepreneurs have some initial networth, tre_t, in order to begin operating.

ratio is the same for all entrepreneurs) is

$$n_t = \gamma^e \frac{1}{\Pi_t} \left\{ \left[1 - \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\right] R_t^k q_{t-1} k_{t-1} - R_{t-1} \frac{b_{t-1}}{p_{t-1}} \right\} + w^e. \tag{1.36}$$

1.3.6 Financial Intermediaries

In our model, financial intermediaries receive deposits from households, a_t, and make loans to entrepreneurs, b_t. Financial intermediaries operate in a perfectly competitive market. Their objective function is given by

$$\left\{ \left[1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] R_{t+1}^l b_t + \left(1 - \mu\right) \int_0^{\varpi_{t+1}} \omega dF\left(\omega, \sigma_{\omega,t}\right) R_{t+1}^k p_t q_t k_t - R_t a_t \right\}, \tag{1.37}$$

which shows expected returns in case of a successful project, plus revenues in case of default, minus the costs in terms of deposits for the financial intermediary.

1.3.7 Government

In this model, the government sets monetary and fiscal policy, and when considered, also macroprudential policy.

Fiscal policy

The government collects taxes, consumes and issues debt according to its intertemporal budget constraint

$$\frac{d_t}{p_t} = g_t + R_{t-1}^d \frac{d_{t-1}}{p_t} - tax_t, \tag{1.38}$$

where d_t denotes current issue of nominal public debt, g_t is government spending, and tax_t represents tax revenues defined by

$$tax_t = \tau_c c_t + \tau_l w_t l_t + \tau_R \left(R_{t-1} - 1\right) \frac{a_{t-1}}{p_t}. \tag{1.39}$$

As in Fernández Villaverde (2010), we assume that government spending follows a fiscal rule

$$\widehat{g}_t = \gamma_g \widehat{g}_{t-1} + d_g \frac{d_{t-1}}{p_t y_t} + d_y \widehat{y}_{t-1} + \sigma_g \varepsilon_{g,t}, \tag{1.40}$$

where $d_g \leq 0$ is the sensitivity of government expenditure to changes in the debt-to-GDP ratio (capturing the objective of public debt stabilization), and $d_y \leq 0$ reflects the countercyclical role of fiscal policy.

Monetary policy

The government is also in charge of monetary policy using as its instrument the nominal interest rate. Monetary policy is set according to a Taylor rule

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\gamma_R} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\gamma_\Pi} \left(\frac{y_t}{y}\right)^{\gamma_y}\right]^{(1-\gamma_R)} \exp(\sigma_m \varepsilon_{m_t}), \tag{1.41}$$

where $\gamma_R \in [0,1]$ is the interest rate smoothing parameter; $\gamma_\Pi \geq 0$ and $\gamma_y \geq 0$ indicate how strong is the response of the interest policy rate to deviations of Π_t and y_t from their steady states, respectively; and σ_m is the volatility of the monetary policy shock, ε_{m_t}. The nominal interest rate is modified through open market operations financed by transfers, T_t.

Macroprudential policy

We depart from Fernández-Villaverde (2010) in that we include a macroprudential department in charge of controlling the volatility and growth of private debt. Through macroprudential instruments we aim at stabilizing private debt volatility in order to guarantee a more stable cycle, so that the private-public debt channel is offset and with it, the amplification effects it has on the economy.

Following Quint and Rabanal (2014), we consider a macroprudential tool affecting the amount of funds available to lend by financial intermediaries in the following way:

$$\frac{1}{\eta_t} a_t = b_t, \tag{1.42}$$

where η_t is a new variable that reflects shifts in credit market conditions caused by

macroprudential policy. Macroprudential regulation will affect financial variables in a countercyclical way. Higher values of η_t reflect a tightening of macroprudential policy, while lower values reflect an easing of macroprudential policy. This macroprudential rule implies that, when the regulation is tightening, financial intermediaries can only lend a fraction of the deposits made by households.[13] In this case, this measure would be equivalent to a reserve requirement ratio.[14]

In line with Quint and Rabanal (2014), we also make η_t dependent on deviations of credit market conditions, Ψ_t, from steady state, Ψ, as follows:

$$\eta_t = \left(\frac{\Psi_t}{\Psi}\right)^{\gamma_\eta}, \tag{1.43}$$

where γ_η reflects how responsive η_t is to the indicator of credit market conditions considered. Notice that macroprudential policies do not affect the steady state since $\eta = 1$ whenever $\Psi_t = \Psi$.

Below, we consider two alternative macroprudential instruments. First, we define Ψ_t as the nominal private credit growth, that is,

$$\Psi_t = \frac{\bar{b}_t}{\bar{b}_{t-1}}\Pi_t, \tag{1.44}$$

where $\bar{b}_t = \frac{b_t}{p_t}$. Consequently, the macroprudential instrument tightens as nominal private credit in the current period grows with respect to nominal private credit in the previous period.

Second, we consider Ψ_t as the private credit-to-GDP ratio, that is,

$$\Psi_t = \frac{\bar{b}_t}{y_t}. \tag{1.45}$$

[13] However, in line with Quint and Rabanal (2014) we also allow the macroprudential instrument to behave symmetrically and go below one. According to this, when the regulation is easing, the monetary authority will provide liquidity to financial intermediaries so that they can lend more funds than the amount of deposits they hold on their balance sheet.

[14] Claessens (2014) classifies the whole set of macroprudential instruments into 5 different categories: restrictions on borrowers (LTV and DTI ratios), capital and provisioning requirements, other restrictions on financial institutions' balance sheets, taxations and levies on activities or balance sheets and other institutional-oriented measures.

In this case, the macroprudential instrument tightens when there is an increase of the private credit-to-GDP ratio.

The introduction of macroprudential policies affects the credit conditions in our model.[15] In particular, the lending-deposit spread becomes

$$\frac{R_{t+1}^{l}}{R_t} = \frac{\eta_t}{\left[1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] + \frac{(1-\mu)}{\varpi_{t+1}} \int_0^{\varpi_{t+1}} \omega dF\left(\omega, \sigma_{\omega,t}\right)}. \tag{1.46}$$

When the macroprudential policy is tightening ($\eta_t > 1$), the lending-deposit spread increases. That is, a tightening of macroprudential policy means less funds are available to lend without any change in the policy rate, widening the gap between lending and deposit rates. The opposite holds when macroprudential policy is easing.

The previous expression shows that the interest rate on loans, R_{t+1}^{l}, also depends on the level of η_t, that is, macroprudential policy affects the contractual agreement. In particular, when the macroprudential rule is restrictive, R_{t+1}^{l} is higher than in the case in which macroprudential policy is relaxed. This way, when we introduce macroprudential policy, even if part of the households' deposits are not borrowed by the entrepreneurs, financial intermediaries can still obtain zero profits at the same cost R_t because the loan rate, R_{t+1}^{l}, has increased. Therefore, despite macroprudential policy, lending funds in the form of deposits to financial intermediaries is still worth it for households. Entrepreneurs, however, face a higher cost on their debt if they need to borrow when macroprudential policy is tightening, and vice versa. As a consequence private credit is affected not only from the supply side but also from the demand side, which is one of the goals of macroprudential policy.

1.4 Aggregation and Equilibrium

Aggregate output in the model is given by

$$y_t = c_t + i_t + g_t + \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\left(r_t + q_t\left(1 - \delta\right)\right) k_{t-1}, \tag{1.47}$$

[15] A detailed explanation can be found in Appendix C.

from the demand side. And the aggregate supply is

$$y_t = \frac{1}{\upsilon_t} e^{z_t} k_{t-1}^{\alpha} l_t^{1-\alpha}, \tag{1.48}$$

where υ_t is the inefficiency created by price dispersion,

$$\upsilon_t = \theta \left(\frac{\Pi_{t-1}^{\chi}}{\Pi_t} \right)^{-\varepsilon} \upsilon_{t-1} + (1-\theta) \left(\Pi_t^* \right)^{-\varepsilon}. \tag{1.49}$$

The equilibrium in this model can be defined as the sequence of quantities $\{c_t,\, l_t,\, a_t,\, k_t,\, i_t,\, b_t\}_{t=0}^{\infty}$; fiscal policy $\{g_t,\, tax_t,\, d_t\}_{t=0}^{\infty}$; prices $\{r_t,\, w_t,\, q_t\}_{t=0}^{\infty}$, and interest rates $\{R_t^d,\, R_t,\, R_t^k,\, R_t^l\}_{t=0}^{\infty}$, given exogenous variables $\{z_t,\, \widehat{\sigma}_{\omega,t}\}_{t=0}^{\infty}$ such that:

- optimization problems for all agents in the model are satisfied;
- all markets clear, that is,

$$y_t = c_t + i_t + g_t + \mu G\left(\varpi_t, \sigma_{\omega,t}\right)\left(r_t + q_t\left(1-\delta\right)\right) k_{t-1},$$

$$y_t = \frac{1}{\upsilon_t} e^{z_t} k_{t-1}^{\alpha} l_t^{1-\alpha},$$

$$l_t^s = l_t^d,$$

$$x_t = (1-\delta) k_{t-1},$$

$$\begin{cases} a_t = b_t & \text{without macroprudential policy,} \\ \frac{1}{\eta_t} a_t = b_t & \text{with macroprudential policy;} \end{cases}$$

- plus the laws of motion of capital and public debt

$$k_t = (1-\delta) k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t,$$

and

$$\frac{d_t}{p_t} = g_t + R_{t-1}^d \frac{d_{t-1}}{p_t} - tax_t.$$

1.5 Calibration and steady state

The model is log-linearized around the non-stochastic steady state, and simulated to exogenous shocks.

Table 1.2 contains the parametrization used in the model. We calibrate most of the parameters based on Gomes and Seoane (2018), Fernández-Villaverde (2010 and 2012) and Bernanke, Gertler and Gilchrist (1999).

Preferences. We set the discount factor to $\beta = 0.999$ and $\Pi = 1.005$ implying an average annual real interest rate equal to 0.4%; habits on consumption are $h = 0.5$, and the Frisch elasticity of labor is $1/\vartheta = 2$. Labor in steady state is $l = \frac{1}{3}$.

Technology. The capital share, α, is set equal to 0.33; the capital depreciation rate, δ, equals 8.9% at an annual rate; and capital adjustment costs are such that $S^{"}[1] = 14.477$. The Calvo pricing parameter, θ, is 0.8 meaning on average 5 quarters of duration of prices; the degree of indexation to past inflation, χ, equals 0.6; and the elasticity of substitution across goods, $\varepsilon = 8.577$, implying a markup of around 13% in the goods sector.

Financial variables. We consider monitoring costs, μ, are 15% of the entrepreneur's output; the loan-to-capital ratio is set equal to $\frac{\bar{b}}{k} = \frac{1}{3}$; the survival rate of entrepreneurs is $\gamma^e = 0.975$ and the annual probability of default is assumed to be 3%.

Fiscal policy. The steady state values for τ_l and τ_r, taken from Fernández-Villaverde (2010), equal 0.24 and 0.32, respectively; the government spending-to-GDP ratio equals 20%, and the debt-to-GDP ratio is 60%. Given these values, τ_c is determined from the government's budget constraint. Parameters d_g and d_y depend on the active or passive fiscal policies characterizing each scenario considered.

Monetary policy. In our analysis below, monetary policy covers different scenarios, mainly active and passive policies, depending on the strength of the response to deviations of inflation from target.

Macroprudential policy. The macroprudential policy parameter, γ_η, is set to 1.75 in all the scenarios considered, so that our results are comparable. As a result, the macroprudential instrument will vary 1.75% for every 1% change in the credit market conditions considered.

Shock processes. We set autoregressive coefficients equal to 0.95, and standard deviations are taken from the empirical evidence and past literature, as summarized in Table 2.

1.6 Credit risk shocks

To assess the implications of the private-public debt channel, we analyze the response of the model economy to credit risk shocks under two possible scenarios, according to either monetary or fiscal dominance in the terminology in Leeper (1991). In the first scenario, we use a standard calibration of the Taylor rule based on the existing literature (Fernández Villaverde, 2012; Christiano, Eichembaum and Rebelo, 2011, among many others). This kind of monetary policy is usually classified as active, following Leeper's definition, as the nominal interest rate reacts strongly to deviations of inflation from its steady state. In turn, the parameters of the fiscal rule are set equal to $d_g = -0.01$ and $d_y = 0$, i.e. fiscal policy is passive, which means that we employ a fiscal rule aiming at stabilizing public leverage. This specification seems to be consistent with the empirical evidence for Spain (Boscá et al., 2018). Therefore, we will refer to this case as Scenario 1 or Spanish scenario.

The second scenario considers a passive monetary policy. We set $d_g = -0.0001$ and $d_y = -0.01$, so that fiscal policy is active. In this case, we implement a fiscal rule which reacts relatively more to fluctuations in GDP than to changes in government debt. We call this policy mix Scenario 2 or U.S. scenario, since it seems consistent with the behavior in the U.S. during the Great Recession (Davig, 2018).

Below, we focus mainly on the response of the economy to credit risk shocks, but we also evaluate the model's predictions in the case of productivity and government spending shocks.

1.6.1 Alternative scenarios without macroprudential policy

Figure 1.1 shows the response of the economy to a 1% standard deviation increase in the credit risk shock, $\sigma_{\omega,t}$, in the absence of macroprudential policies. The figure displays the two policy scenarios just described: Spanish scenario/Scenario 1 (dashed) and US scenario/Scenario 2 (solid).

When the economy is hit by an increase in credit risk in the private sector, the probability of default of borrowers rises. Lenders toughen the terms of the contract by increasing the state-contingent threshold value of the idiosyncratic shock (not shown in the figures) and the interest rate paid on loans. This generates a decrease in total private debt and therefore, a decrease in private investment. As a consequence, GDP falls on impact, in line with Christiano et al. (2010) and Gomes and Seoane (2018).

The fall of private loans also leads to a consequent decrease in the price of capital (Tobin's q). The firm's networth is directly related to the Tobin's q, as the latter establishes the value of the assets of the entrepreneur. So, even if both private loans and networth go down, the shock generates a shift from the share of capital investment financed by the entrepreneur's own resources to the share of capital investment financed by external funds. As a consequence, the external finance premium goes up. The credit risk shock generates a decrease in labor. Therefore, output falls below its steady state for the first ten periods approximately. Tax collection also contracts following the same path as output, and consequently, public debt goes up in the event of a risk shock. Summing up, lower private debt depresses investment and output. Tax revenues fall, pushing upwards public debt. Fiscal consolidation to control public leverage implies further adjustments in output.

The monetary and fiscal policy mix considered is practically irrelevant for the behavior of private debt, even though it translates into slightly different paths for the policy-related variables, with no significant change in the rest of aggregates. In particular, monetary and fiscal policies do not seem to substantially affect the financial sector in any of the scenarios considered, except for the effect of the debt

deflation channel. Under Scenario 1, the active monetary policy cancels the effects of inflation on public debt and the passive fiscal policy does not stabilize the latter completely. Regarding Scenario 2, the passive monetary policy allows inflation to counteract only slightly the rise in public leverage caused by the active fiscal policy.

In both scenarios, the private-public debt channel is at work. Public and private debt move in opposite directions. Notice that, the channel operates no matter what combination of fiscal and monetary policy is in place, as Figure 1.1 shows. In the absence of an explicit response to financial conditions, none of the monetary-fiscal policy mixes considered here is able to offset the amplifying effects of financial frictions in the event of a credit shock.

1.6.2 Alternative scenarios with macroprudential policy

We next analyze the previous scenarios when macroprudential policy is included in the model. As mentioned in Section 1.3.7, we consider macroprudential instruments aiming at stabilizing credit market conditions and not addressing GDP directly.

Dynamics to credit risk shock

Firstly, we introduce a macroprudential tool targeting nominal credit growth, as in equation (1.44). In a second step, we consider a macroprudential instrument focusing on the credit-to-GDP ratio, given by equation (1.45). These two macroprudential cases are represented in the figures by a dashed line and a dotted line, respectively. The results obtained are displayed in Figures 1.2 and 1.4 for Scenarios 1 and 2 respectively, and explained below. Figures 1.3 and 1.5 show the evolution of the credit market conditions under the two macroprudential regimes for each of the monetary-fiscal scenarios considered.

The introduction of macroprudential instruments has clear effects on the financial sector. Private debt is almost completely stabilized when the credit-to-GDP ratio is the objective. This is not the case when authorities focus on the growth rate of nominal debt although, its volatility is reduced with respect to the no macropru-

dential case. In both occasions, macroprudential policies respond to the downturn by easing credit conditions, putting less pressure on investment in response to the shock. This is passed on to output, alleviating public revenues, and allowing for a timid fiscal expansion without incurring in too much public debt.

In both scenarios, targeting nominal private debt growth isolates networth and the Tobin's q from the negative effects of the shock. This contributes to output stabilization. Targeting nominal credit growth also increases loanable funds after a credit risk shock, but less than under the credit-to-GDP ratio. The effects of the shock are moderated, but not sufficiently to generate enough taxes as to feedback into more output. As a consequence, the response of the economy is smoothed, attaining more overall stability.

The simulations show that the two macroprudential policies considered here can break the private-public debt channel found in the data. However, each macroprudential tool has different implications in terms of economic stability. When the credit-to-GDP ratio is the target, the positive correlation between private and public debt comes at the cost of more output volatility. The opposite is true under a macroprudential policy regime tracking nominal credit growth. Procyclical tax collection is key in this channel as it can contribute to the stabilizing effects of macroprudential policies by allowing for a fiscal expansion without excessive public debt.

Volatility and correlations

Table 1.3 confirms the results described above. It reports the standard deviations of output, inflation, private and public debt after a credit risk shock under the scenarios considered. The macroprudential instrument which stabilizes output the most is the one reacting to nominal credit growth. Targeting deviations of credit-to-GDP attains the highest private debt stabilization. However, as mentioned above, this is at the cost of higher output volatility.

Finally, we look at the correlation between the private debt-to GDP ratio and the public debt-to-GDP ratio to evaluate if the private-public debt channel can be off-

set in any of the scenarios considered (see Table 1.4). These ratios correspond to measures similar to the data presented in Section 1. We find that macroprudential policy is able to cancel out the negative correlation between both variables. Moreover, the macroprudential tool which stabilizes nominal credit growth is the one that offsets this channel the most, mainly by smoothing the path of public debt, as the correlation goes from negative to around 0.91. Targeting the credit-to-GDP ratio offsets the private-public debt channel mainly by smoothing the path of private debt. This translates into positive although lower correlations than the ones just described. These results reflect the debate on the choice of the macroprudential tool, given the different results obtained in this model in terms of economic stability.

The objective of this chapter is not to derive the optimal policy mix. However, we do go deeper into the analysis of macroprudential policies and assess the robustness of our results to alternative parameterizations of the macroprudential policy instrument and to different preferences of the policymaker.

Robustness analysis

To shed some light on these last points, we next investigate the validity of the results to different parameterizations of γ_η. We follow standard procedure in the literature (Iacoviello, 2005) and compute policy frontiers in terms of the volatility of output and that of the macroprudential policy target for a grid of values of γ_η in the interval $[0, 2]$. The results are displayed in Figure 1.6. In the figure, the first row corresponds to the growth of nominal private debt as the policy objective, and the second row refers to the credit-to-GDP ratio. The columns refer to the two scenarios considered: active monetary policy/passive fiscal policy (left) and passive monetary policy/active fiscal policy (right). The colors in the plots become lighter the larger is γ_η. The triangle highlights the combination corresponding to the current benchmark calibration of the model.

The trade-off between output and instrument stabilization is clear in the four cases considered, but depends on the value of γ_η. When credit-to-GDP is the target, macroprudential policy does not need to be so aggressive to stabilize output: the

model just requires $\gamma_\eta \geq 0.05$, versus $\gamma_\eta \geq 0.79$ for the nominal credit growth target. However, the target becomes more volatile (the vertical axis in the second row of the graph is around twice that in the first row). There are some values for which there is no trade-off between output and target stabilization. In both cases, higher values of γ_η attain lower output volatility, pointing in favor of aggressive macroprudential policies over the cycle. It is worth mentioning that for the nominal credit growth target under the passive monetary policy/active fiscal policy combination (Scenario 2), there are some discontinuities around $\gamma_\eta = 1$ that lead to excessively large σ_y.[16]

Finally, we compute the loss attained in terms of volatility when the economy is affected by credit risk shocks.[17] We assume a macroprudential authority who cares about output volatility and the variance of the policy instrument as follows:

$$\mathcal{L} = (1 - \phi_y)\sigma_\Psi^2 + \phi_y \sigma_y^2, \tag{1.50}$$

where $\phi_y \in [0, 1]$ represents the relative weights of σ_y and σ_Ψ in the objective function;[18] and where Ψ_t is given either by equation (1.44) or equation (1.45). We calculate the loss under the alternative policy-mix scenarios considered and for a range of parameters relating the relative weights of the objectives in the loss function. The results appear in Table 1.9.

The table displays absolute values for $\mathcal{L}$ in the cases of no macroprudential policy, when macroprudential policy targets nominal credit growth, and finally, when the objective is the ratio of credit-to-GDP. To assess the change in volatlity of using macroprudential policies, we compute the percentage deviation of the loss under each policy target for the benchmark calibration with respect to the no-macroprudential policy case.

[16] These extreme points have been excluded from the current graph.

[17] We follow here the approach in Angelini et al. (2014). This exercise is motivated by the trade-off found above between the volatility of output and that of the macroprudential target in the event of credit risk shocks. The objective of this exercise is to understand the volatility implications of alternative preferences of the policymaker over output versus macroprudential target volatility, not to derive the optimal policy. The optimal policy assessment is, however, a relevant analysis which is left for future research.

[18] Equation (1.50) represents a loss in the sense that less volatility is preferred to more.

We observe that active monetary/passive fiscal policies reduce overall loss when nominal credit growth is the target, no matter which is the value of ϕ_y, what implies that this type of macroprudential instrument is effective in stabilizing both its target and output. The macroprudential instrument that reacts to the credit-to-GDP ratio, reduces overall loss as long as the macroprudential authority also cares about target stabilization, but not if the policymaker is only concerned about output stabilization (this is consistent with the output destabilization in Table 1.3 under Scenario 1 when credit-to-GDP is the target). The passive monetary/active fiscal combinations work in favor of the credit-to-GDP ratio, only for $\phi_y = 0$, that is, when the macroprudential authority is not concerned about GDP stability. However, once more, when $\phi_y = 1$ and macroprudential policy responds to the credit-to-GDP ratio the overall loss goes up significantly (again this is consistent with the output destabilization in Table 1.3 under Scenario 2 when credit-to-GDP is the target).

1.7 Other shocks

Our analysis is complemented by the study of the response of the economy to a technology and a government spending shock. Active/passive monetary-fiscal policy mixes yield different results depending on the shocks affecting the economy.[19] Indeed, the results contrast with those obtained for the active/passive fiscal-monetary policy mixes under a credit risk shock.

1.7.1 Technology shock

Figures 1.7 to 1.11 report the impulse response functions under both scenarios, with and without macroprudential policies in place. After a positive technology shock, output goes up and inflation falls. There is a boom in the economy also favored by the decreasing nominal interest rates. Under both scenarios, the debt deflation and interest rate channels are active. However, the different reaction of real interest rates yields diverging stabilization results. Our findings are consistent with

[19] We thank an anonymous referee for bringing out this point.

those in Gomes and Seoane (2018) and Davig and Leeper (2011), among others. In particular, passive monetary-active fiscal policies (Scenario 2) mitigate the effects of a technology shock on output and do not stabilize inflation as much as the combination of active monetary-passive fiscal (Scenario 1). Our private-public debt channel is only present under Scenario 1, not under Scenario 2. When considered, macroprudential policies react by tightening credit supply, in order to stabilize the economy. This tightening contributes to output and both public and private debt stabilization for Scenario 1, but this is not the case for Scenario 2.

Tables 1.5 and 1.6 confirm these results for a technology shock. Specifically, Table 1.6 shows that, in the event of this shock, the negative relation between private and public debt can become positive by using different combinations of active/passive fiscal and monetary policies. However, after a technology shock, macroprudential policy is not enough to break the channel. These results are the opposite to the ones obtained for a credit risk shock. Moreover, Table 1.5 implies that, except for private debt, macroprudential policy is more effective in the reduction of the volatility of the main macroeconomic variables under Scenario 1, independently of how it is implemented.

1.7.2 Government spending shock

The results are displayed in Figures 1.12 to 1.16. Regarding an exogenous increase in government spending, the model displays the well-known crowding-out effect on consumption and investment. Inflation goes up pushing interest rates up, and this is more so under Scenario 1 than Scenario 2. These results are consistent with those in Davig and Leeper (2011). The fiscal expansion raises public debt under both scenarios, with private debt reacting in the opposite way. That is, our private-public debt channel is present under both scenarios. Again, the destabilization is greater under Scenario 2, due to the less strong response of monetary policy. Macroprudential indicators respond by easing credit conditions.

Similarly, Tables 1.7 and 1.8 show the main standard deviations and the correlations between private and public debt in the event of a government spending shock. Once

more, as opposed to the results obtained under a credit risk shock, Table 1.8 shows that after a government spending shock, the private-public debt channel is affected by the fiscal-monetary policy mix rather than by the introduction of macroprudential policy. Table 1.7 reflects the fact that macroprudential policy always reduces the volatility of private debt but it lowers public debt volatility only under Scenario 1.

Summarizing, Tables 1.6 and 1.8 show that the private-public debt channel is present under Scenario 1 but not under Scenario 2 for both technology and government spending shocks. Therefore, traditional policy mix can affect the channel under these shocks even if it cannot under credit risk shocks. Moreover, from Tables 1.5 and 1.7 we observe that under technology and government spending shocks the cancellation of the channel not always implies a higher financial or macroeconomic stabilization. The results also show that the macroprudential instruments generate a trade-off between private debt and GDP stabilization not only under credit risk shocks but also for the case of both technology and government spending shocks.

1.8 Conclusion

During the period between 2007 and 2017 some countries, such as the US or Spain, implementing widely contrasting fiscal policies, show a negative relation between their own levels of private and public debt. Based on these empirical facts, this chapter shows that macroprudential policy is a complementary tool to the monetary-fiscal policy mix when the objective is to stabilize private and public debt at the same time.

We build a model with financial frictions, in which fiscal and monetary policies interact in response to a credit risk shock that brings an economic recession. As a consequence, a private-public debt channel arises by which private and public debt move in opposite directions, so the traditional macroeconomic policies cannot stabilize both variables at the same time. The intuition for this is the fact that when private debt decreases in response to a restrictive credit risk shock, investment must go down, reducing output. As taxes in our model are proportional, the fall

of GDP implies a reduction in public revenues and the consequent rise of public debt. We find that the standard mix of monetary and fiscal policies is not enough to stabilize both variables at the same time.

We then introduce macroprudential policy responding either to the nominal private credit growth or to changes in the private credit-to-GDP ratio. The analysis of these macroprudential tools is performed for two different scenarios that combine active/passive fiscal and monetary policies. The results show that macroprudential policy, under both designs, affects the lending-deposit spread in a way that offsets, at least partially, the private-public debt channel in the two scenarios considered, stabilizing private debt more than when there is no macroprudential policy in place. Nevertheless, macroprudential authorities need to consider both the interaction of macroprudential tools with the monetary and fiscal policies in place. They also need to decide on the correct credit market variables that macroprudential policy should address, depending on whether they prioritize economic stability or financial stability. A macroprudential tool that reacts to the nominal credit growth is the most efficient in offsetting the private-public debt channel and it does so by stabilizing public debt. This macroprudential tool is the one that most stabilizes the business cycle by decreasing output volatility, especially when it is combined with a passive monetary policy and an active fiscal policy (Scenario 2). However, a macroprudential tool that targets the credit-to GDP ratio offsets the channel by stabilizing private debt. This is the macroprudential tool that stabilizes private debt the most, specially under an active monetary policy and a passive fiscal policy (Scenario 1).

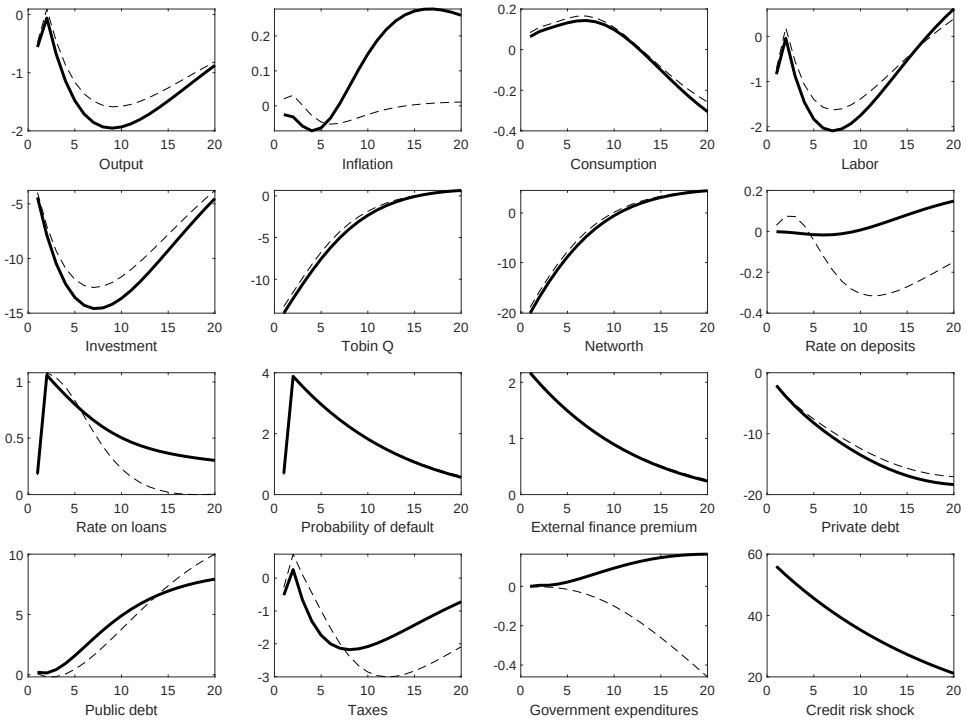
Finally, to complement our credit risk shock analysis we compare it to the cases of a technology and a government spending shock. We observe that different policy mixes of traditional monetary and fiscal policies do affect the channel in the event of these other shocks. In particular, the private-public debt channel is is active under Scenario 1 but is offset when we change to Scenario2. However, the cancellation of the channel does not always imply financial or economic stabilization. Regarding macroprudential policies, in the same as under credit risk shocks, after technology

and government shocks, these measures always stabilize private debt more than the baseline no macroprudential case. Moreover, we find again the same trade-off between output and private debt stabilization as in the event of a credit risk shock: the macroprudential instrument that reacts to the credit-to-GDP ratio gets to stabilize more private debt while the macroprudential instrument that targets the nominal credit growth stabilizes output the most. Despite the coincidence of these results with the ones obtained for a credit risk shock, after technology and government shocks, macroprudential policy can be responsible of a higher macroeconomic destabilization.

Of course, in Scenario 1 monetary policy reacts to domestic conditions, but actually, the European Central Bank does not react to individual country's conditions. We leave for further research the replica of this analysis in an economy, like Spain, where monetary policy is constrained by membership in a currency area. Chapter 2 analyzes the latter adapting the model to the EMU countries, in what refers to monetary policy.

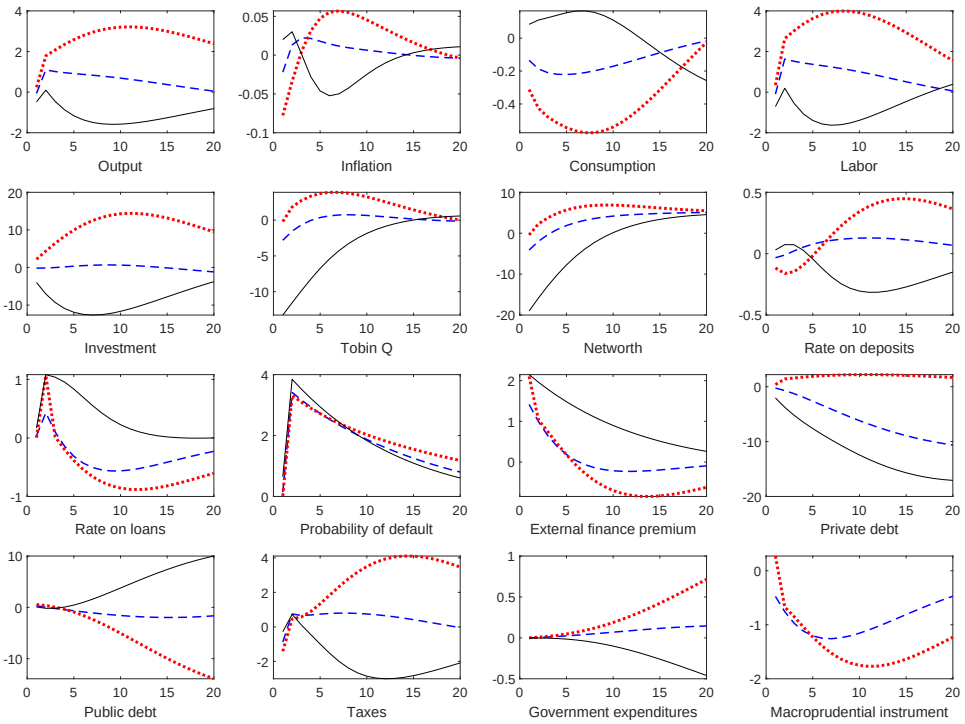
Figures

Figure 1.1: Impulse response functions to a 1 std. deviation rise in credit risk. Scenarios without macroprudential policy.



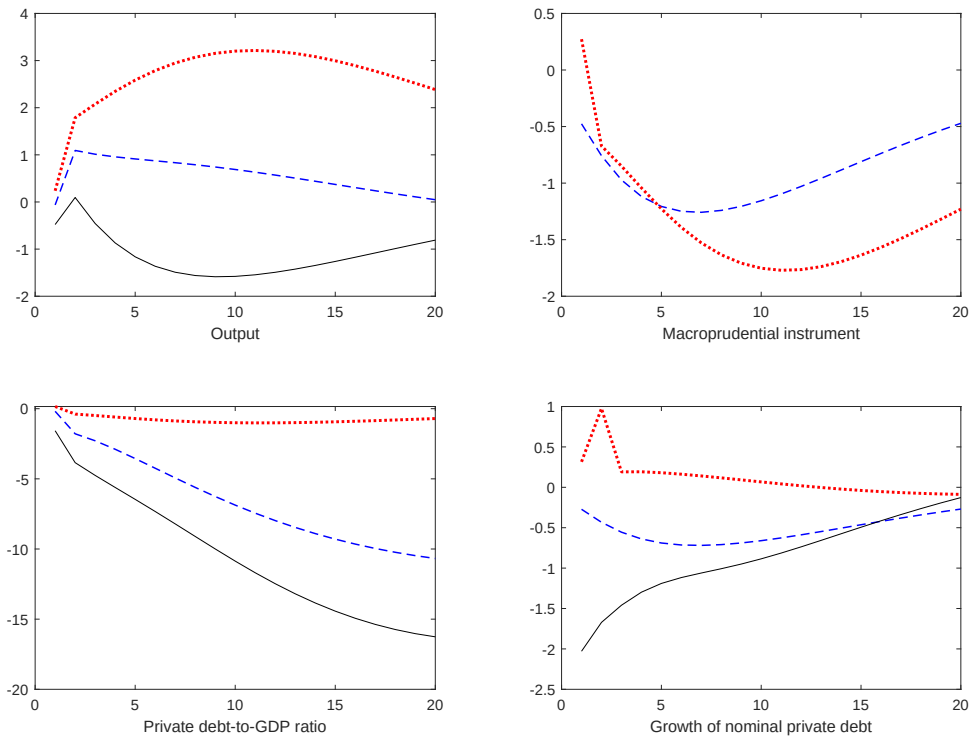
Note: The lines plotted in these graphs depict the IRFs for the cases without macroprudential policy. The dashed line refers to Scenario 1, the solid line to Scenario 2. "Taxes" refers to total tax revenues given by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.2: IRFS to a 1 standard deviation rise in credit risk. Scenario 1.



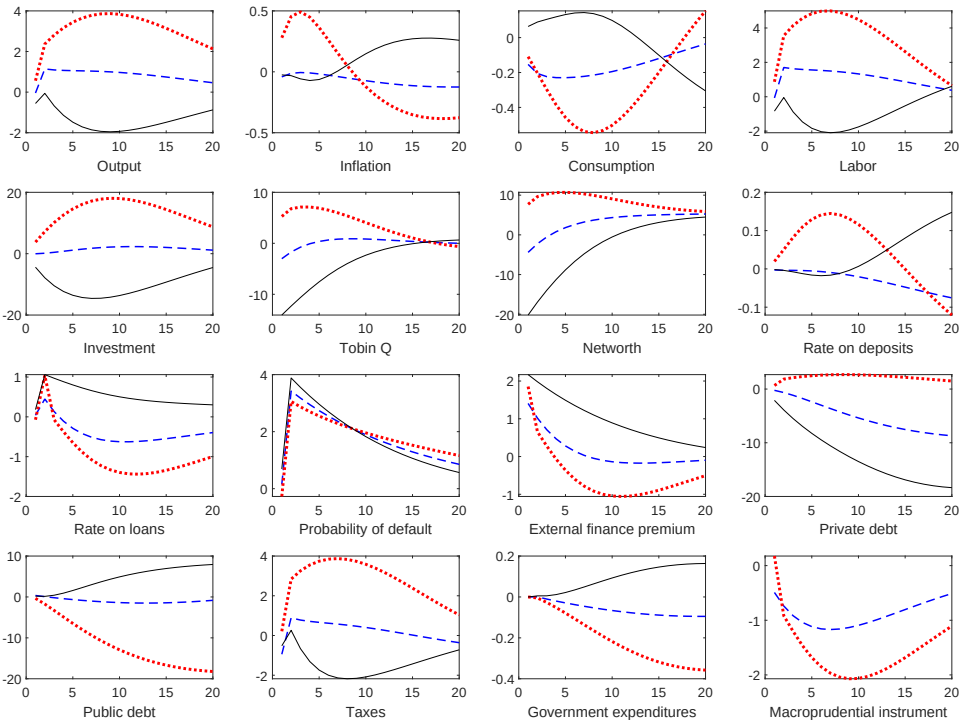
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. "Taxes" refers to total tax revenues as defined by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.3: IRFS to a 1 standard deviation rise in credit risk. Credit market conditions in Scenario 1.



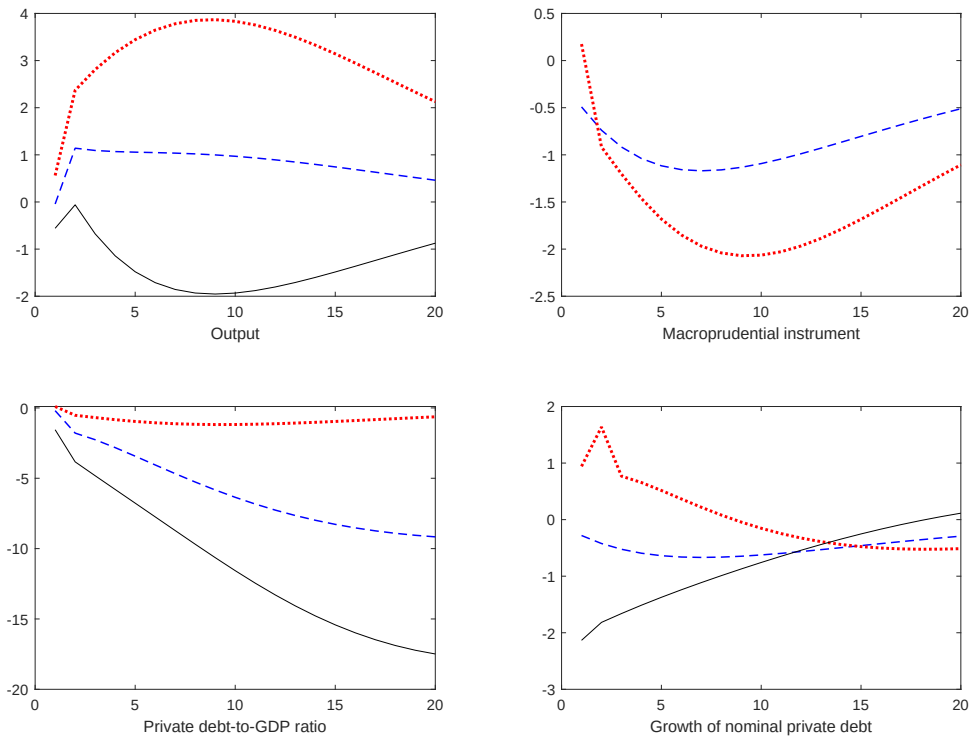
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. Variables are expressed in percentage points of deviations from steady state.

Figure 1.4: IRFS to a 1 standard deviation rise in credit risk. Scenario 2.



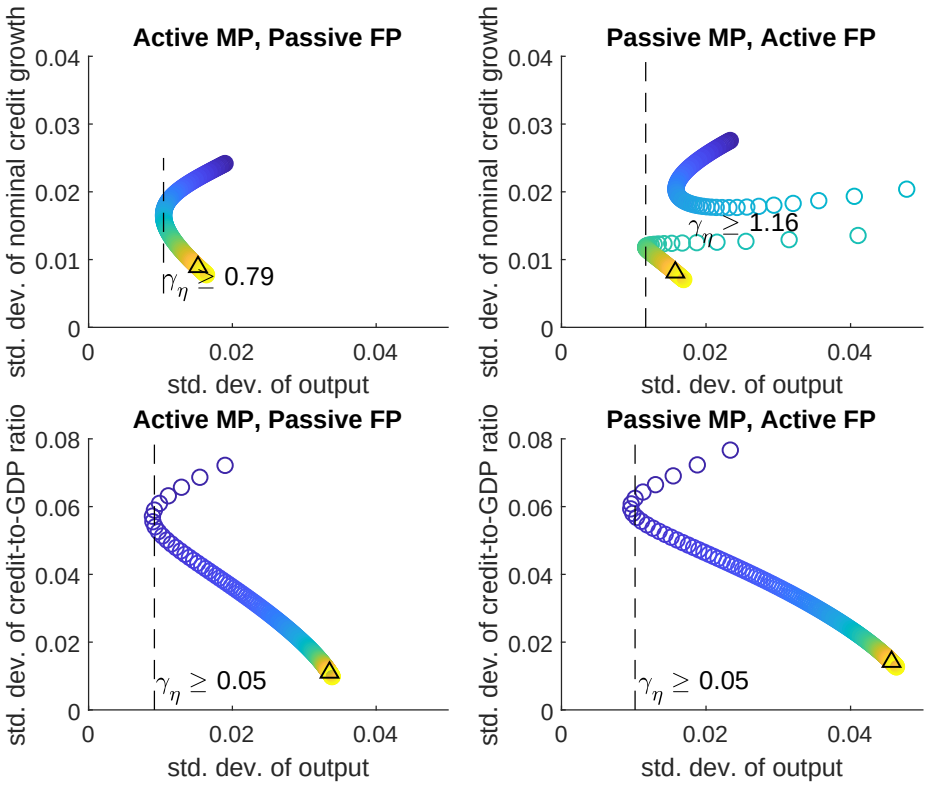
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. "Taxes" refers to total tax revenues as defined by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.5: IRFS to a 1 standard deviation rise in credit risk. Credit market conditions in Scenario 2.



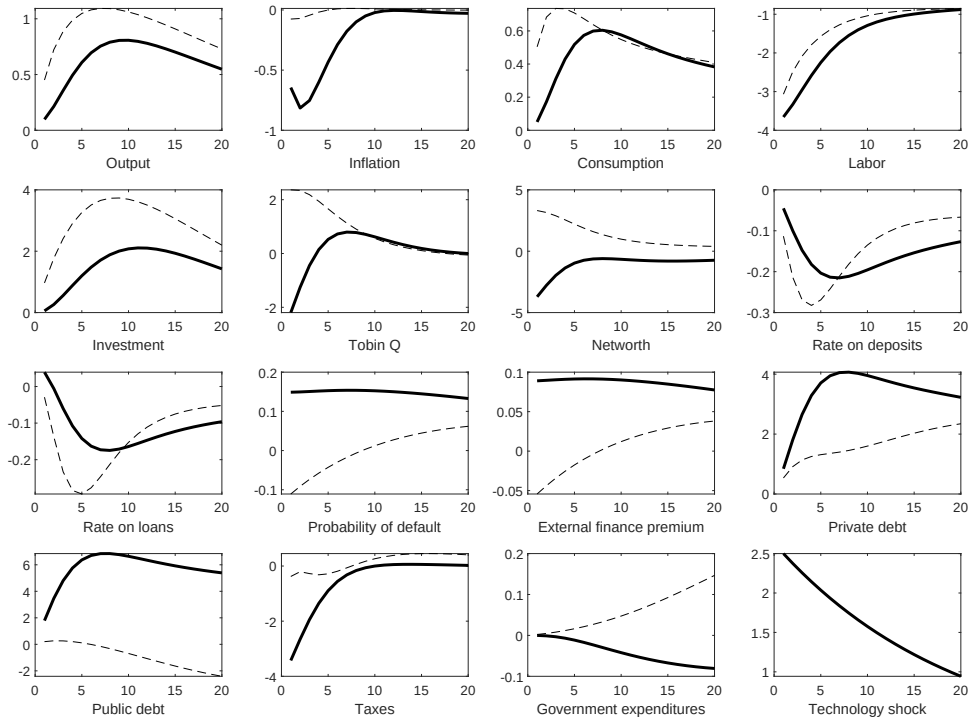
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. Variables are expressed in percentage points of deviations from steady state.

Figure 1.6: Robustness results to alternative γ_η under a credit risk shock.



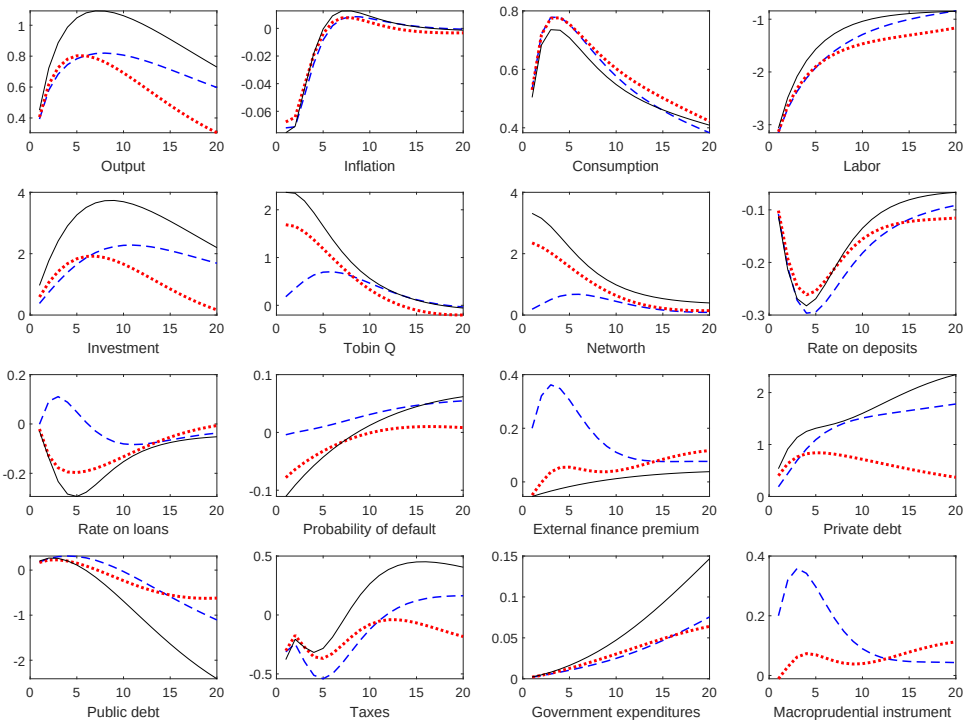
Note: The first row corresponds to growth of nominal private debt as the policy objective, and the second row refers to the credit-to-GDP ratio. The colors in the plots become lighter the larger is γ_η. The triangle highlights the combination that corresponds to the current benchmark calibration of the model. The vertical line delimits relevant outcomes given the range of values for γ_η.

Figure 1.7: Impulse response functions to a 1 standard deviation rise in technology. Scenarios without macroprudential policy.



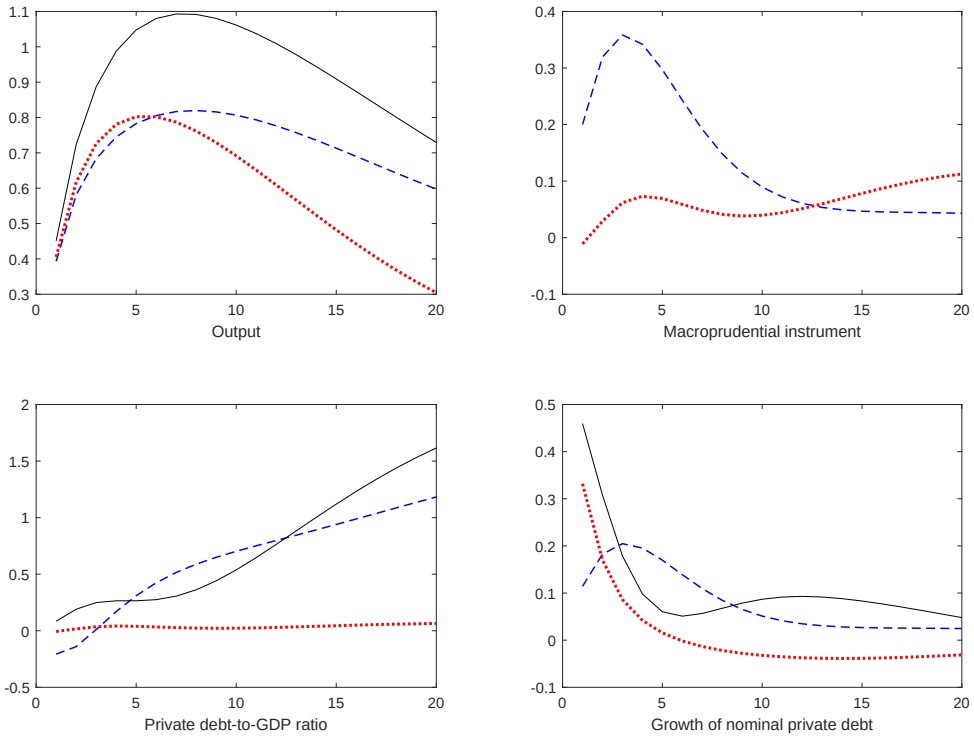
Note: The lines plotted in these graphs depict the IRFS for the cases without macroprudential policy. The dashed line refers to Scenario 1 and the solid line refers to Scenario 2. "Taxes" refers to total tax revenues as defined by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.8: IRFS to a 1 standard deviation rise in technology. Scenario 1.



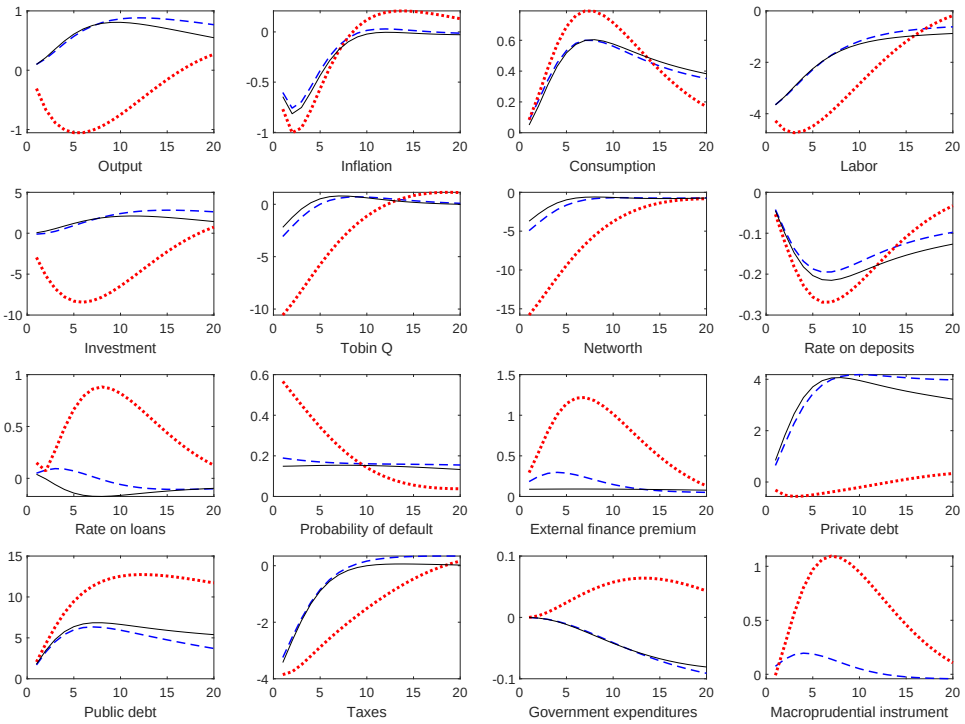
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. "Taxes" refers to total tax revenues as defined by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.9: IRFS to a 1 standard deviation rise in technology. Credit market conditions in Scenario 1.



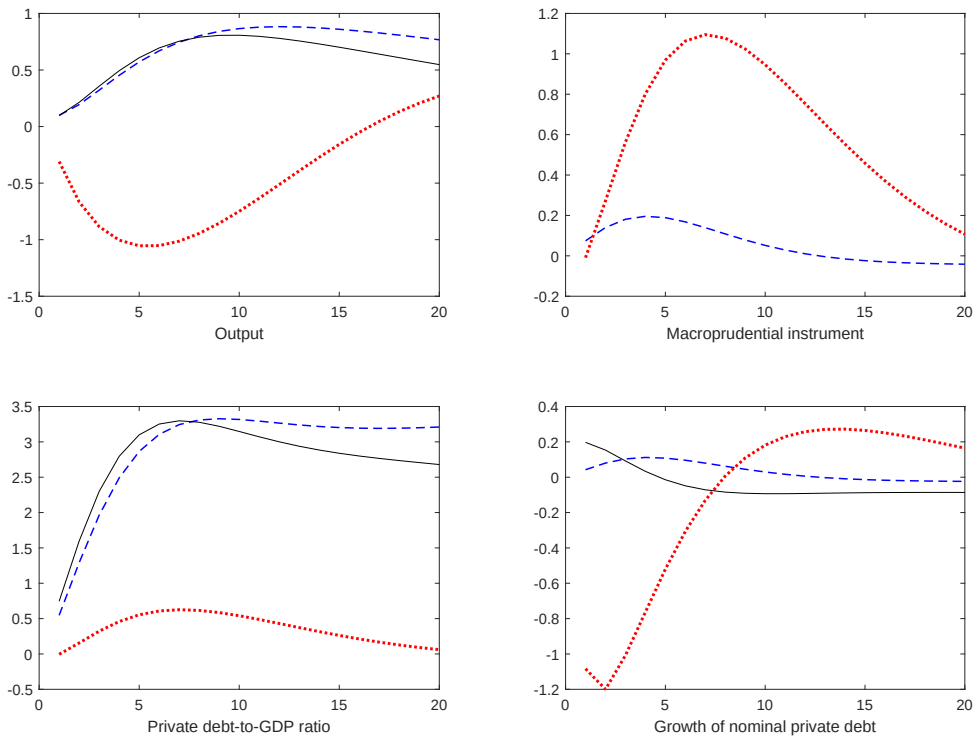
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. Variables are expressed in percentage points of deviations from steady state.

Figure 1.10: IRFS to a 1 standard deviation rise in technology. Scenario 2.



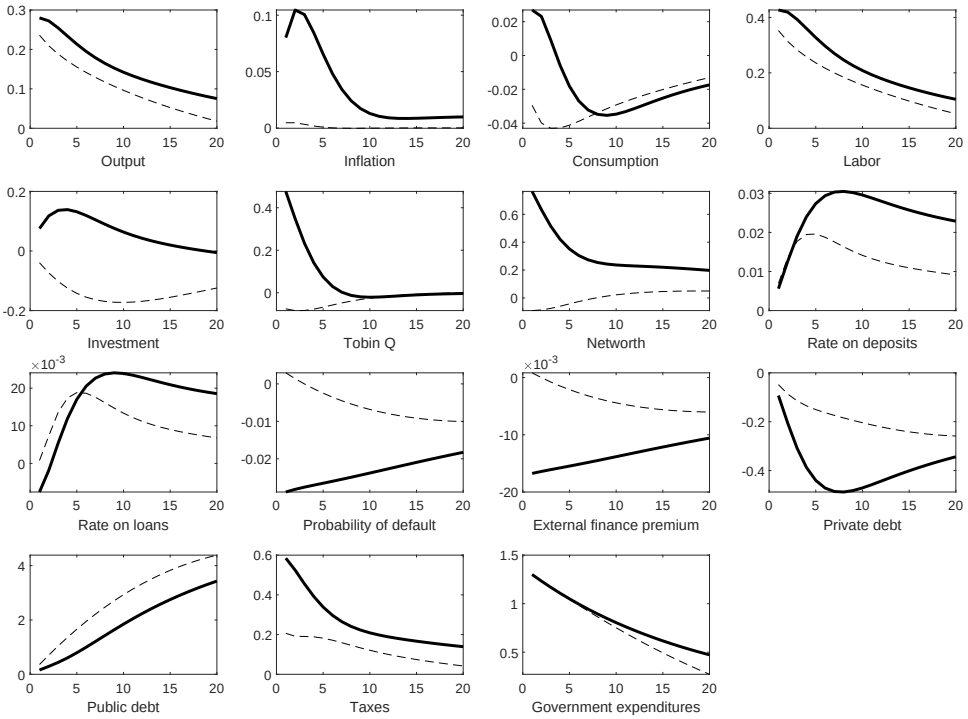
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. "Taxes" refers to total tax revenues as defined by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.11: IRFS to a 1 standard deviation rise in technology. Credit market conditions in Scenario 2.



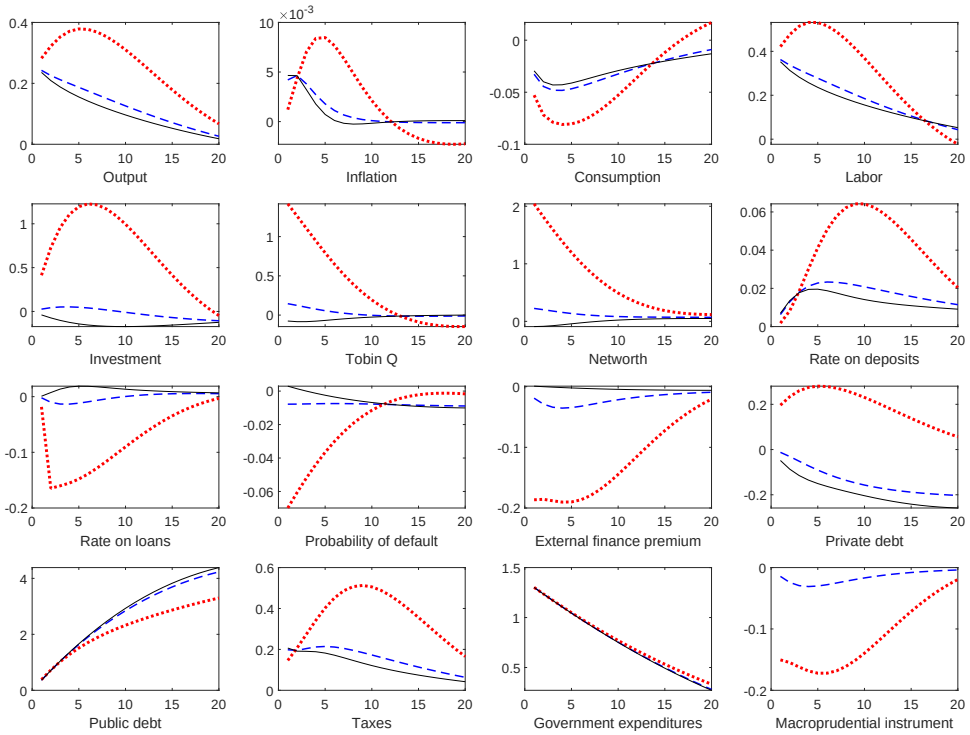
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. Variables are expressed in percentage points of deviations from steady state.

Figure 1.12: Impulse response functions to a 1 standard deviation rise in government spending. Scenarios without macroprudential policy.



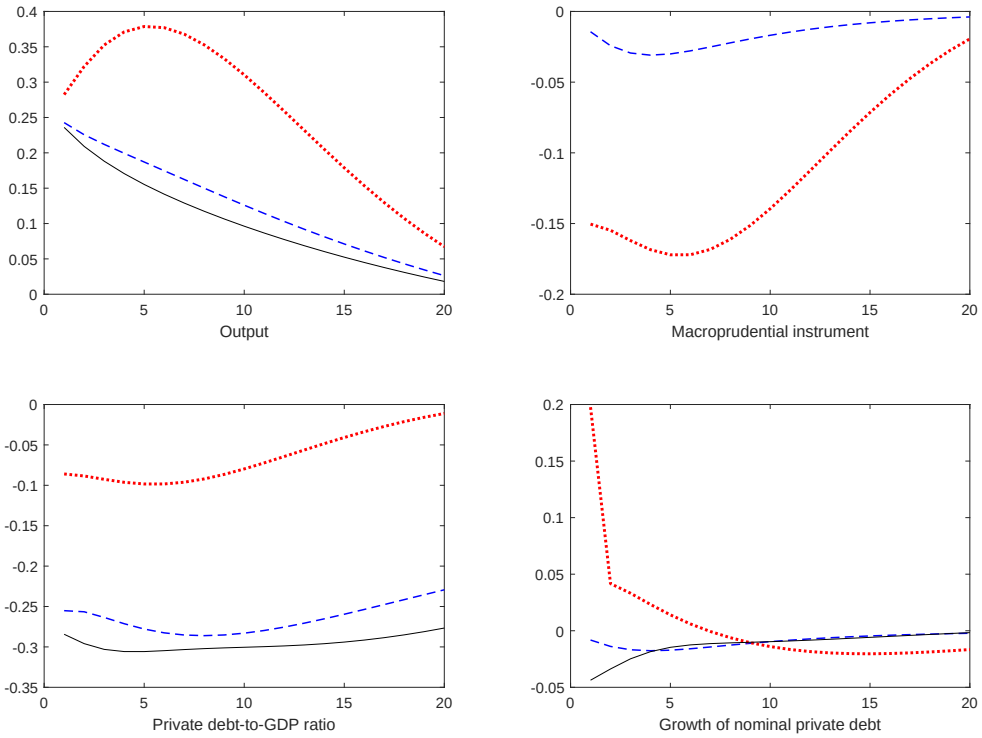
Note: The lines plotted in these graphs depict the IRFS for the cases without macroprudential policy. The dashed line refers to Scenario 1 and the solid line refers to Scenario 2. "Taxes" refers to total tax revenues as defined by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.13: IRFS to a 1 standard deviation rise in government spending. Scenario 1.



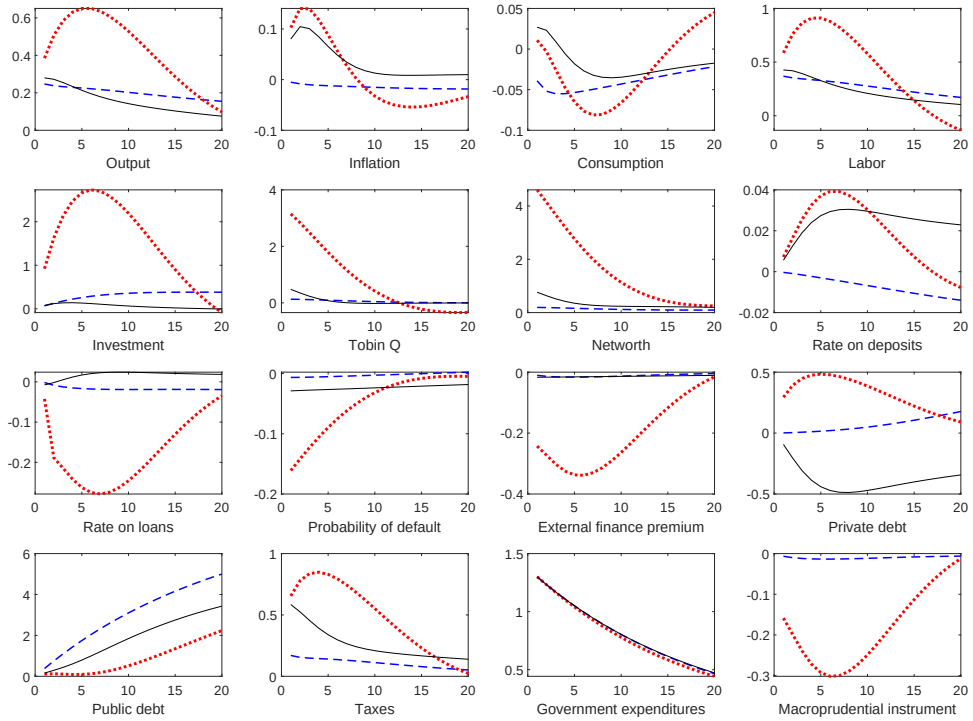
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. "Taxes" refers to total tax revenues as defined by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.14: IRFS to a 1 standard deviation rise in government spending. Credit market conditions in Scenario 1.



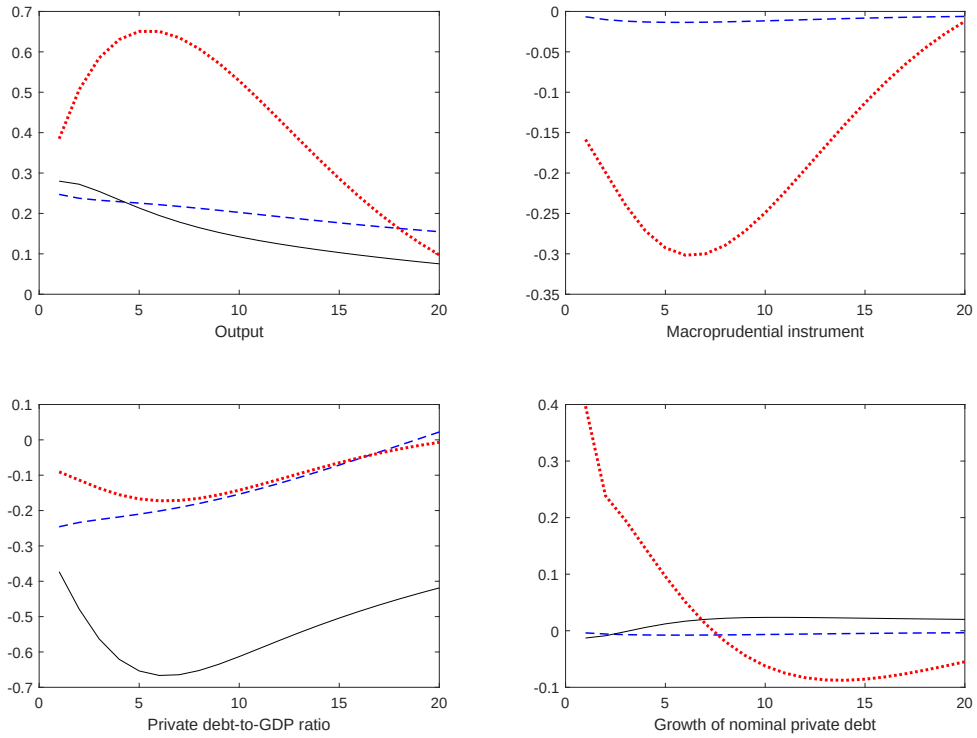
Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. Variables are expressed in percentage points of deviations from steady state.

Figure 1.15: IRFS to a 1 standard deviation rise in government spending. Scenario 2.



Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. "Taxes" refers to total tax revenues as defined by equation (1.39). Variables are expressed in percentage points of deviations from steady state.

Figure 1.16: IRFS to a 1 standard deviation rise in government spending. Credit market conditions in Scenario 2.



Note: The dashed line refers to the case in which macroprudential policy targets the nominal credit growth, the dotted line to the case in which macroprudential policy targets the credit-to-GDP ratio and the solid line to the model without macroprudential policy. Variables are expressed in percentage points of deviations from steady state.

Tables

Table 1.2: Calibration of the parameters and steady states for Chapter 1

Parameter	**Description**	**Value**	**Source**
β	Discount factor	0.999	Fernández-Villaverde (2010)
h	Consumption habits	0.5	Fernández-Villaverde (2010)
ϑ	Frisch elasticity of labor	0.5	Fernández-Villaverde (2010)
α	Capital share of the intermediate production function	0.33	Fernández-Villaverde (2012)
δ	Capital depreciation rate	0.023	Fernández-Villaverde (2012)
θ	Calvo pricing parameter	0.8	Fernández-Villaverde (2010)
ε	Elasticity of substitution across goods	8.577	Fernández-Villaverde (2012)
χ	Degree of indexation	0.6	Fernández-Villaverde (2010)
$pdef$	Annual probability of default	0.03	Bernanke et al. (1999)
μ	Bankruptcy costs	0.15	Fernández-Villaverde (2012)
γ^e	Survival rate of entrepreneurs	0.975	Fernández-Villaverde (2010)
τ_l	Steady state of labor income tax rate	0.24	Fernández-Villaverde (2010)
τ_r	Steady state of capital income tax rate	0.32	Fernández-Villaverde (2010)
Π	Target gross inflation	1.005	Fernández-Villaverde (2012)

Parameter	Description	Value	Source
l	Time devoted to work	1/3	Fernández-Villaverde (2010)
q	Tobin's q. Price of capital	1	Fernández-Villaverde (2010)
R^d	Steady state of interest rate on public debt	$\frac{\Pi}{\beta}$	Fernández-Villaverde (2010)
R	Steady state of interest rate on deposits	$\frac{R^d-1}{1-\tau_R}+1$	Fernández-Villaverde (2010)
$\frac{\bar{b}}{\bar{k}}$	Loan-to-capital ratio	1/3	Fernández-Villaverde (2010)
$\frac{g}{y}$	Government expenditure-to-GDP ratio	0.2	Gomes and Seoane (2018)
$\frac{d}{y}$	Public debt-to-GDP ratio	0.6	Gomes and Seoane (2018)
$S^{"}$ [1]	Capital adjustment costs	14.477	Fernández-Villaverde (2012)
γ_g	Persistence parameter of government spending shock	0.95	Fernández-Villaverde (2012)
σ_g	Volatility of government spending shock	0.007	Gomes and Seoane (2018)
ρ_z	Persistence of technology shock	0.95	Fernández-Villaverde (2012)
σ_z	Volatility of technology shock	0.007	Gomes and Seoane (2018)
ρ_σ	Persistence of credit risk shock	0.95	Fernández-Villaverde (2012)
η_σ	Volatility of credit risk shock	0.560	Gomes and Seoane (2018)
γ_R	Persistence of monetary policy shock	0.95	Fernández-Villaverde (2012)

Parameter	**Description**	**Value**	**Source**
σ_m	Volatility of monetary policy shock	0.003	Gomes and Seoane (2018)
$\gamma_\Pi (1 - \gamma_R)$	Response of intervention rate to changes in inflation	1.5 or 0.07	Scenario analysis
d_g	Response of government spending to changes in public debt	-0.01 or -0.0001	Scenario analysis
d_y	Response of government spending to changes in output	0 or -0.01	Scenario analysis
γ_η	Response of macroprudential tool to changes in credit market conditions	0 or 1.75	Own calibration

Table 1.3: Standard deviations for alternative policy mixes under a credit risk shock.

Variable	No macroprudential tool	Credit-to-GDP ratio	Nominal credit growth
Scenario 1: active monetary - passive fiscal policies			
Output	0.0190	0.0335 (77%)	0.0152 (-20%)
Inflation	0.0010	0.0014 (39%)	0.0004 (-57%)
Public debt	0.0490	0.0641 (31%)	0.0252 (-49%)
Private debt	0.0722	0.0110 (-85%)	0.0457 (-37%)
Scenario 2: passive monetary - active fiscal policies			
Output	0.0234	0.0457 (95%)	0.0158 (-33%)
Inflation	0.0034	0.0096 (179%)	0.0009 (-75%)
Public debt	0.0558	0.1278 (129%)	0.0271 (-51%)
Private debt	0.0767	0.0142 (-81%)	0.0440 (-43%)

Note: These results are the standard deviations to a standard deviation credit risk shock with $\eta_\sigma = 0.560$. The numbers in brackets represent the percentage variation for each variable volatility with respect to its baseline scenario value.

Table 1.4: Correlation between public and private debt under a credit risk shock.

	No macroprudential tool	Credit-to-GDP ratio	Nominal credit growth
Scenario 1	-0.6351	0.3447	0.9117
Scenario 2	-0.8251	0.8506	0.9147

Note: Scenario 1 refers to the active monetary/passive fiscal policy mix and Scenario 2 refers to the passive monetary/active fiscal policy mix.

Table 1.5: Standard deviations for alternative policy mixes under a technology shock.

Variable	No macroprudential tool	Credit-to-GDP ratio	Nominal credit growth
Scenario 1: active monetary - passive fiscal policies			
Output	0.0124	0.0105 (-15%)	0.0092 (-26%)
Inflation	0.0011	0.0009 (-18%)	0.0010 (-9%)
Public debt	0.0105	0.0081 (-23%)	0.0046 (-56%)
Private debt	0.0065	0.0006 (-91%)	0.0064 (-2%)
Scenario 2: passive monetary - active fiscal policies			
Output	0.0083	0.0172 (107%)	0.0077 (-7%)
Inflation	0.0117	0.0161 (38%)	0.0111 (-5%)
Public debt	0.0345	0.1249 (262%)	0.0651 (89%)
Private debt	0.0650	0.0089 (-86%)	0.0316 (-51%)

Note: These results are the standard deviations to a standard deviation technology shock with $\sigma_z = 0.025$. The numbers in brackets represent the percentage variation for each variable volatility with respect to its baseline scenario value.

Table 1.6: Correlation between public and private debt under a technology shock.

	No macroprudential tool	Credit-to-GDP ratio	Nominal credit growth
Scenario 1	-0.6008	-0.3012	-0.3689
Scenario 2	0.9969	0.9210	0.9708

Note: Scenario 1 refers to the active monetary/passive fiscal policy mix and Scenario 2 refers to the passive monetary/active fiscal policy mix.

Table 1.7: Standard deviations for alternative policy mixes under a government spending shock.

Variable	No macroprudential tool	Credit-to-GDP ratio	Nominal credit growth
Scenario 1: active monetary - passive fiscal policies			
Output	0.0030	0.0054 (80%)	0.0032 (7%)
Inflation	0.0001	0.0001 (0%)	0.0001 (0%)
Public debt	0.0186	0.0122 (-34%)	0.0177 (-5%)
Private debt	0.0038	0.0015 (-61%)	0.0035 (-8%)
Scenario 2: passive monetary - active fiscal policies			
Output	0.0037	0.0093 (151%)	0.0032 (-14%)
Inflation	0.0015	0.0025 (67%)	0.0001 (-93%)
Public debt	0.0129	0.0168 (30%)	0.0178 (38%)
Private debt	0.0078	0.0025 (-68%)	0.0034 (-56%)

Note: These results are the standard deviations to a standard deviation government spending shock with $\sigma_g = 0.013$. The numbers in brackets represent the percentage variation for each variable volatility with respect to its baseline scenario value.

Table 1.8: Correlation between public and private debt under a government spending shock.

	No macroprudential tool	Credit-to-GDP ratio	Nominal credit growth
Scenario 1	-0.1883	-0.1833	-0.2318
Scenario 2	0.2091	0.9458	-0.0569

Note: Scenario 1 refers to the active monetary/passive fiscal policy mix and Scenario 2 refers to the passive monetary/active fiscal policy mix.

Table 1.9: Loss function for alternative scenarios and parameter values under a credit risk shock.

Macroprudential policy scenario	γ_η	AM/PF $\phi_y = 0$	AM/PF $\phi_y = 0.5$	AM/PF $\phi_y = 1$	PM/AF $\phi_y = 0$	PM/AF $\phi_y = 0.5$	PM/AF $\phi_y = 1$
No macroprudential							
Nominal credit growth	0	0.0006	0.0005	0.0004	0.0008	0.0006	0.0005
Credit-to-GDP	0	0.0052	0.0028	0.0004	0.0059	0.0032	0.0005
Nominal credit growth	1.75	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002
Overall volatilty change		*-86.42%*	*-67.09%*	*-35.75%*	*-91.36%*	*-75.96%*	*-54.50%*
credit-to-GDP ratio	1.75	0.0001	0.0006	0.0011	0.0002	0.0011	0.0021
Overall volatilty change		*-98.08%*	*-78.57%*	*175%*	*-96.61%*	*-65.62%*	*320%*

Note: The changes in overall volatility are computed for each scenario with respect to the corresponding non-macroprudential case. In the table, AM/PF stands for active monetary/passive fiscal policies (Scenario 1), and PM/AF refers to the case of passive monetary/active fiscal (Scenario 2).

Chapter 2

Stabilization and the policy mix in a monetary union

2.1 Introduction

After the financial crisis of 2007, countries of the European Monetary Union (hereinafter EMU) followed very different recovery patterns in terms of restitution of their pre-crisis levels of GDP, inflation or unemployment.[1] For instance, by 2011, Germany had already reached its 2007 GDP level but Spain was still immersed in a national income fall (see Bozio et al., 2015). These GDP paths are illustrated in Figure 2.1. The research is motivated by the fact that, during the years that followed the Great Recession, countries belonging to the EMU experienced those economic recovery divergences.

The stabilization differences in the EMU have called into question the ability of the traditional policies (monetary and fiscal) to stabilize by themselves a monetary union. There is an open debate about how authorities can complement the different national fiscal policies when monetary policy is centrally implemented and cannot address the particular needs of each country. Many authors claim a new instrument is needed to complement monetary policy in a monetary union and to prevent, more

[1] Henceforth, I will refer to this restitution as the "economic recovery".

than cure, the effects that a financial crisis may bring not only to the financial sector but also to the whole economy. Chapter 2 contributes to this debate by analyzing alternative policy mixes that pursue financial and macroeconomic stabilization in a monetary union in which monetary, fiscal and macroprudential policy interact.

The novelty of this work is that it models a monetary union hit by asymmetric shocks and where, given that monetary policy cannot be used by national authorities, fiscal and macroprudential policy interact to stabilize their economies. My model shows that a positive financial shock, that increases the credit risk of the private sector, can generate a *private-public debt channel* through which the economy is destabilized. This channel represents a barrier to stabilize the financial sector and the whole economy and fiscal and monetary policy alone cannot cancel it. The reason is that a financial crisis might impose the obligation for private deleveraging, destabilizing the economy. On the one hand, the limits of fiscal policy do not allow to counteract deleveraging by issuing more public debt and, on the other hand, the central bank may not overuse non-conventional monetary policy. I find that it is possible to stabilize GDP and the financial sector by offsetting the private-public debt channel so an additional instrument is needed.

The private-public debt channel operates in the following way:[2] after a financial shock that reduces the level of private debt, investment goes down what is translated in a lower level of GDP. The decrease of GDP causes a drop in the collection of taxes and the consequent rise of public debt. This inverse relation between private and public debt amplifies the business cycle and slows down the recovery of GDP. In my open economy model, the spillover effects of a financial shock that increases credit risk, originated in the home country, transmit this channel beyond the national borders. When fiscal authorities undertake a fiscal consolidation through government spending to reduce the levels of public debt, they contribute to an even deeper fall of GDP. As taxes are proportional, public revenues also go down so there is a further rise of public debt. If, on the other hand, fiscal authorities expand public expenditures to restore GDP, they might provoke a new increase in public debt that

[2]See Chapter 1.

might not be compensated by the increase in public revenues. As fiscal policy may not be enough to offset the private-public debt channel, I propose the introduction of an alternative policy that does alter it: macroprudential policy. Furthermore, due to the open economy dimension of my model, I show that macroprudential policy can sometimes stabilize the economy even if the channel is not offset. This is the case in which macroprudential policy addresses union-wide aggregates. The stabilization is then achieved through an *open economy channel*.

Table 2.1 shows how the private-public debt channel is present in Germany and Spain (see the correlation between private and public debt for each country (B-D)), for the subsample 2007-2017, a decade characterized by a financial crisis mainly originated by a financial shock. By contrast, the channel is not present in any of the countries during the whole period 1960-2017. As explained in Chapter 1, the change in the correlation between private and public debt, during the Great Recession, may be the result of the private deleveraging process that the financial crisis imposed. However, the whole period 1960-2017, may have been affected in a higher proportion by different shocks that counteracted the effects of financial shocks so that the channel did not arise. The table also displays the correlation between public debt and output (D-Y) and government spending and output (G-Y), respectively, in Germany and Spain, for both the whole period 1960-2007 and the subsample 2007-2017. Finally, it is possible to observe that, during the period of the Great Recession, the German GDP followed a more stable path than the Spanish one.

These countries are affected by the same monetary policy but different government spending policies during the periods being analyzed. Column (G-Y) shows that during the sub-period 2007-2017, Germany used countercyclical government spending policies and Spain used them procyclically, and both resulted in negative correlations of private and public debt. Thus, in line with the findings in Chapter 1, the cyclicality of government spending might not be the main cause for the negative correlation that Germany and Spain presented between private and public debt during the subperiod 2007-2017. Therefore, as the private-public debt channel may not

Table 2.1: Contemporaneous correlation among main debt and output aggregates and standard deviation of GDP in Germany and Spain

Period 1960-2017				
	$\rho(B,D)$	$\rho(D,Y)$	$\rho(G,Y)$	$\sigma(GDP)$
Germany	0.309	-0.526	-0.250	0.025
Spain	0.327	-0.377	0.092	0.027
Sub-period 2007-2017				
	$\rho(B,D)$	$\rho(D,Y)$	$\rho(G,Y)$	$\sigma(GDP)$
Germany	-0.173	-0.487	-0.521	0.019
Spain	-0.511	-0.677	0.672	0.037

Note: B denotes real private debt-to-real GDP ratio; D is real public debt-to-real GDP ratio; Y represents real GDP, and G is real government consumption. Both real GDP, Y, and real public consumption, G, have been detrended using the Hodrick Prescott filter. To evaluate real private and public debt I use their ratio over GDP. Source: See Appendix A.

depend on the cyclicality of government spending, it seems that these kind of fiscal measures cannot eliminate the channel by themselves.

The negative correlation between public debt and GDP in both countries implies that when GDP goes down public debt increases, among other things, consequence of a fall in tax collection. With a countercyclical government spending that stabilizes output after a recession, public debt may rise because taxes do not compensate the increase in public deficit. With a pro-cyclical government spending that goes down with output, the reduction of government spending may result in a still lower level of GDP, a decrease in public revenues and therefore public debt may rise. This may explain why the channel operates in both Germany and Spain, even if the undertook opposite government spending strategies.

Table 2.1 also contains the GDP volatility for each country. The inverse relation of private and public debt in Spain during the sub-period 2007-2017 comes together with a more volatile cycle than for the whole period 1960-2017. However, in Germany, even if private and public debt are negatively correlated during the sub-period 2007-2017, GDP remains more stable than in the previous years. This is understandable, among other reasons, given that Germany implemented a series of structural reforms between years 2002 and 2007 to the labor market and strengthened public finances (Bozio et al., 2015).

Motivated by the previous data, this chapter considers how authorities can stabilize their economies through the implementation of macroprudential policies. With that aim, I build a two-country DSGE model of a monetary union following the set up used in Quint and Rabanal (2014) with financial frictions, modelled as in Bernanke, Gertler and Gilchrist (1999). I introduce a macroprudential tool to control the amount of loans that the banking system can lend to the private sector by targeting the growth of nominal credit. Unlike Quint and Rabanal (2014) my research compares a scenario in which macroprudential policy is implemented at the national level with a scenario in which it is implemented centrally (federal implementation), analyzing how both situations interact with national fiscal policies in a monetary union. In my model, fiscal policy, implemented at the national level, follows a government spending rule aimed at stabilizing public debt. Monetary policy, implemented at the union level, is set according to a standard Taylor rule. There are international financial markets that work as in Quint and Rabanal (2014): international financial intermediaries take the surplus of private funds from one country and supply those funds to the other country that has a shortage of funds. This implies that when macroprudential policy is implemented in one country, the effects of this measure are transferred to international financial markets, generating spillovers to the other country.

The analysis focuses on the case of a positive credit risk shock, which increases the level of credit risk, and is originated in the country acting as net international borrower, that enters into a recession. The international borrower in my model represents a periphery country, such as Spain, and the international lender a core country, such as Germany.[3] The other country of the union is indirectly affected by the financial shock too. In this framework, I compare different macroprudential scenarios, given an active (inflation targeting) monetary policy, as the one implemented in the EMU and two national passive fiscal policies, in line with Leeper (1991).

[3]As Bordo (2014) states *"There has been a build-up of TARGET liabilities since 2007 by some central banks (notably Greece, Ireland, Portugal, and Spain, or the GIPS), and of TARGET assets by Germany and others"*.

Figure 2.2 shows that the level of private debt-to-GDP ratio in Spain at the beginning of the financial crisis was significantly large compared to Germany. When an economy enters into a recession the initial economic conditions are a key determinant in the posterior speed of the economic recovery and stabilization (Bordo and Haubrich, 2012). Hence, macroprudential measures are important in stabilizing the economy, not only during busts but also during booms, to prevent initial economic conditions from accentuating the negative effects of a financial recession. In line with this, the IMF (2013) defines the aim of macroprudential policy as prevention rather than cure, so macroprudential policy has an important role ensuring that the initial levels of debt of an economy are not excessive. By shrinking private leverage in good times, macroprudential measures may help economies to maintain private leveraging stable. This way they will not enter into a financial crisis with such high levels of debt and economic stability will be more easily achieved . Moreover, as Bordo and Haubrich (2012) explain, the steeper the expansion, the deeper the posterior recession.

In my model, the economic recovery achieved by the countries depends to a large extent on the macroeconomic policies implemented by them and their neighbors in response to the shock that triggers the recession. In a monetary union, countries cannot use their own monetary policy, and fiscal policy is left alone to face the problem of economic instability. But fiscal policy cannot affect the financial sector by itself (see Chapter 1), and financial sector stabilization is crucial to smooth the business cycle after a financial shock. This is why macroprudential policy can play an important role.

My results show that, after a financial recession, macroprudential policy brings back both financial and macroeconomic stability. This is because it manages to change the response of the private sector variables to financial shocks and sometimes even breaks the private-public debt channel. It is worth mentioning that the introduction of fiscal instruments is crucial for this analysis as its interaction with the financial variables is the cause for the private-public debt channel. Considering that there is no common consensus on how the new toolkit should be designed, I shed light on

the different stabilization effects of alternative macroprudential policy scenarios in a monetary union. Thus, I analyze a first case of national macroprudential policy that succeeds in offsetting the private-public debt channel and brings financial and economic stabilization in both countries. Then, I study a second case in which macroprudential policy is implemented at the union level and does not manage to break the channel in any of the countries. In this case, macroprudential policy brings the greatest economic stabilization to the country that suffers the shock while it destabilizes the other country.

Chapter 2 is organized as follows. In Section 2.2, I review the most significant literature that is closely related to this research. Section 2.3 includes the description of the open economy model. In Section 2.4, I add macroprudential policy to the baseline model. Section 2.5 contains the equilibrium and market clearing conditions of the model. Section 2.6 presents the calibration. In Section 2.7, I analyze the effects that a credit shock causes in the main economic variables of an economy that belongs to a monetary union. Section 2.8 concludes.

2.2 Related literature

This work contributes to the DSGE literature that studies the macroprudential policy stabilization effects in a monetary union. More concretely, Chapter 2 of this dissertation fits in the macroprudential literature that discusses whether these policies attain more stability when they are implemented at the national level or at the union level.

This model is an open economy version of the Fernández-Villaverde (2010) and Gomes and Seoane (2018) new Keynesian model with financial frictions modelled as in Bernanke, Gertler and Gilchrist (1999). Fernández-Villaverde (2010) studies the effects of fiscal policy focusing on the use of distortionary taxes and a fiscal rule for government spending in the presence of financial frictions. He finds that government spending shocks are more powerful in stimulating output than tax shocks. Similarly, I analyze the effects of fiscal policy in a model with financial frictions but for an

open economy within a monetary union that is hit by a financial shock. I also study the stabilization properties of the policy mix but including macroprudential policy to observe its interaction with traditional policies. I borrow the relevance of risk shocks as a key element in the propagation financial instability from Christiano et al. (2010). These authors find that the risk shock is responsible for a great part of the business cycle fluctuations both in the Euro Area and in the US. They argue that the recent economic crisis was mainly driven by a risk or financial credit shock. This motivates the introduction of these shocks in my model and the use of macroprudential policy to fight against their destabilizing effects.

This chapter studies a channel previously analyzed in Chapter 1 by which the public and private sector are negatively correlated after a credit risk shock. Corsetti, Kuester, Meier and Müller (2012) also analyze a *sovereign risk channel* through which higher sovereign default risk raises the financing costs of the private sector resulting in an adverse effect on economic activity. Unlike Corsetti et al. (2012), I study the inverse relation in the levels of sovereign and private debt. Their framework refers to the zero lower bound (ZLB) but they stress that their analysis could carry through other situations where monetary policy is constrained. Similarly, I analyze how the channel operates when monetary policy is constrained, because countries belong to a monetary union, and I consider an alternative instrument to offset this channel: macroprudential policy.

The private-public debt channel of my model is a consequence of a connection between the financial sector and the public sector caused by fiscal instruments in my model. The channel, that propagates the destabilizing effects of the shock from the financial sector to the broader economy, cannot be offset by using only fiscal policy. To understand why fiscal policy is unable to cancel the channel it is worth emphasizing that fiscal policy can be classified as active or passive, as defined by Leeper (1991) and applied to an extensive literature (Gomes and Seoane, 2018). Countercyclical fiscal policies aimed at boosting GDP during recessions are active. This kind of policy generates still higher levels of public debt and, depending on the size of the multiplier, may not manage to boost output and increase public rev-

enues. The stabilization of output through active fiscal policies implies a trade-off: when the aforementioned channel works, the increase in public debt coincides with a decrease in private debt that constrains investment and can make output go down even deeper. On the other hand, when fiscal policy is passive, in Leeper's terminology, it targets public debt stabilization. In a recession, when the level of output has fallen substantially and the economy supports high levels of public debt, a fiscal consolidation will be implemented to reduce the latter. But this fiscal strategy could reduce the GDP level even more and thus the collection of taxes, increasing public debt. Therefore, the procyclical fiscal policy might not achieve its objective of public debt reduction.

Gomes and Seoane (2018) argue that different combinations of active/passive monetary and fiscal policies (based on Leeper (1991) definitions) are able to explain the different recovery paths across countries. They advocate that, after the Great Recession, the US experienced a faster economic recovery than the EMU due to the accelerator effects of financial frictions combined with an active fiscal regime. By contrast, Euro Area was characterized by implementing a passive fiscal regime. I also analyze different economic recovery paths originated by the divergences in the policy mix, motivating my research in the evolution of two EMU countries after the Great Recession: Germany and Spain. Moreover, my model differs from Gomes and Seoane's model in the use of proportional taxation, and in that I consider a public spending rule (instead of a lump-sum tax rule). Another important difference that determines my results is that I develop an open economy model while these authors analyze the policy mix in a closed economy.

Regarding the open economy literature, Galí and Monacelli (2005) model a continuum of small open economies to analyze the fiscal-monetary policy mix when monetary policy is set by a common central bank. They find that, under nominal rigidities, the lack of a national monetary policy requires that national fiscal policy assumes the stabilization role. I argue that, after a credit risk shock, stabilization, in terms of reduction of GDP and debt volatility, cannot be attained only by national fiscal policies. Therefore, what most differentiates my study from theirs is that

I introduce macroprudential policy for the search of macroeconomic and financial stability in the monetary union.

I lay out a two-country model for a monetary union with an international goods market and incomplete international financial markets, in line with Quint and Rabanal (2014). Their financial accelerator mechanism differs from the one proposed by Bernanke, Gertler and Gilchrist (1999), and that I use in my model, because they abstract from asymmetric information. Thus, there is no default in their model unless borrowers find themselves completely underwater (that is, borrowers do not lie about their realized profits). However, in my model there is asymmetric information, and therefore aggregate risk, what makes financial intermediaries pay an auditing cost to verify that borrowers do not lie about their realized return. As a consequence, these monitoring costs result in a direct loss for the aggregate national output in my model. In addition, the predetermined rate on loans included in Quint and Rabanal allows domestic financial intermediaries to obtain profits or losses. I simplify this assumption, even if it is less realistic, with a rate on loans that depends on the state of the economy so that domestic financial intermediaries deliver zero profits. This allows to characterize these agents as mere intermediaries between households (who lend funds) and entrepreneurs (borrowers).

Quint and Rabanal (2014) study the effects of a risk shock and observe that the active monetary policy (based on the anti-inflationary monetary policy of the EMU) cannot contain the accelerator effects of the economy. This is why they introduce macroprudential policy. They propose two alternative ways of macroprudential instrument design: one that targets the credit-to-GDP ratio and another that reacts to changes in the nominal credit growth. They argue that macroprudential policy delivers economic stability. Thus Quint and Rabanal (2014) study the use of macroprudential policy, however, they do not consider the effects of a fiscal rule. I focus my analysis on the use and effects of macroprudential policy, but as a complement to fiscal policy driven by a government spending rule. The interaction between fiscal and macroprudential policies is important given that they represent the whole set of instruments on which national authorities can count in the context of a mon-

etary union. Moreover, fiscal policy plays an important role in my model as it is responsible for the private-public debt channel through which the destabilizing effects of the risk shock are propagated to the economy. Nevertheless, even including an additional national tool (fiscal policy) I find that, after a financial shock that increases the level of credit risk in a country of a monetary union, macroprudential instruments are needed. They complement traditional policies in the pursue of financial and economic stability because fiscal policy cannot attain this objective by itself.

The macroprudential instrument that I use is also based on Quint an Rabanal (2014) because it controls the amount of loans in the economy. I focus my analysis on the nominal credit growth as the financial indicator. This is consistent with the Basel III broad macroprudential goal of protecting the banking sector from excessive credit growth. Basel III also states that "national authorities should monitor credit growth" and refers to it as an indicator that signals a build-up of system-wide risk. Monitoring credit growth is how macroprudential policy in my model pursues its objective of reducing macroeconomic and financial volatility.

As opposed to Quint and Rabanal (2014), I shed light on the differences between national versus federal macroprudential policies. Other contributions to this debate about the convenience of implementing macroprudential policy at the union level or individually can be found within the recent macroprudential literature. Rubio (2014) analyzes the role of macroprudential policy in a heterogeneous monetary union comparing a scenario in which this policy is centralized against a scenario in which it is decentralized. The author concludes that the best option depends on the type of heterogeneity of the currency union. Rubio (2014) analyzes the effects of macroprudential policy when the union is hit by asymmetric technology shocks. However, my analysis revolves around the role of macroprudential policy after a credit risk shock, although I provide a robustness study for alternative asymmetric shocks. Conversely, Brzoza-Brzezina, Kolasa and Makarski (2013) also develop a two-country model for a monetary union and find that macroprudential policy can be viewed as a stabilizing tool only when it is implemented nationally. As opposed

to them, I observe that a federal macroprudential policy may stabilize one of the countries of the monetary union.

Dehmej and Gambacorta (2017) are part of the growing literature that states that monetary policy cannot lean against the wind to provide stability to the financial sector. This statement is further reinforced by the situations in which asymmetric shocks hit the monetary union as monetary policy reacts only to average conditions. These authors also compare country-targeted macroprudential policy versus federally implemented macroprudential policy in a monetary union. They conclude that the former brings more advantages than the latter in terms of enhancing stability. My results imply that financial stability is stronger when macroprudential policy targets national variables but countries that are more destabilized after the shock can attain higher macroeconomic stability with a federal macroprudential policy. Unlike Dehmej and Gambacorta (2017), I model imports and exports in the goods market and an international debt market which are determinant in the stabilization attained by macroprudential policy. But I coincide with them in the fact that national macroprudential policy is more appropriate than federal macroprudential policy to stabilize the countries of a monetary union after asymmetric shocks. It seems unfair to implement the same federal macroprudential policy targeting aggregate financial variables when not all the countries of the monetary union have the same needs.

Rubio and Carrasco-Gallego (2016) build a two-country model to compare the welfare gains when all the Euro Area countries coordinate in the implementation of national macroprudential policies to the welfare gains of the case in which there is no coordination. In the non-coordination case, a country does not implement macroprudential policy. They define macroprudential coordination as the situation in which each member state applies an equivalent macroprudential policy to that set by the others, responding to its own credit variables. The authors find that macroprudential policy always delivers financial stability but there are more welfare gains when all countries coordinate than when one country does not implement macroprudential policy. But, although that country does not coordinate, it benefits from its

partners' policy implementation as the result is a more stable financial system than when there is no macroprudential policy in place. Similarly to these authors, I also shed some light on the implications of a non-coordinated scenario that can lead one country to free-ride. However, I consider that economies and shocks are not symmetric so my results go further. I find that the spillover effects of macroprudential policy to the country that does not implement it depend on whether this country is the one responsible for the financial shock or not. This implies that not all countries can free-ride because, in the event of asymmetric shocks, the country in which the financial shock is originated is stabilized only if it implements macroprudential policy. Indeed, in my model, this country is not affected by what other countries do, so it is the only one that can mend its unstable situation. The only possible free-riders in this context are the countries not responsible for the financial shock because they attain financial stability when the others (that cause its instability) implement macroprudential policy[4].

Regarding the role of macroprudential instruments in the policy mix, there is an extensive literature that analyzes the interaction between monetary and macroprudential policies. Angelini et al. (2012) argue that, under financial shocks, the macroprudential and monetary policy coordination brings more macroeconomic stability than a "monetary-policy-only" scenario. Quint and Rabanal (2014) conclude that macroprudential policy reduces macroeconomic volatility and supports monetary policy by requiring smaller responses of the interest rate. I share with them the view that macroprudential policy is necessary when monetary policy cannot stabilize so effectively the financial system. But unlike all of them I add fiscal policy to the analysis of the policy mix.

Despite the extensive literature on the interaction of macroprudential and monetary policies, there is no much about how to coordinate macroprudential and fiscal policies. This chapter also contributes to the scarce literature about the interaction of fiscal and macroprudential policies. Claessens (2014) mentions the importance of

[4]Appendix E includes an analysis to compare the effects of macroprudential policy implemented coordinately versus macroprudential policy implemented only in one of the countries of the monetary union.

coordinating macroprudential actions with other policies, such as fiscal or microprudential. Regarding fiscal policy and according to this author, some tax policies can contribute to systemic risk by encouraging private leverage and therefore macroprudential authorities need to coordinate with fiscal authorities. My work sheds new light on policy mix coordination: I show that in a monetary union where monetary policy cannot be used by national authorities, fiscal policy cannot stabilize public and private debt at the same time. This is why the following sections explore different ways of implementing a new tool, macroprudential policy, and how it interacts with the fiscal and monetary instruments in place.

2.3 The model

Based on the closed economy model of Fernández-Villaverde (2010), I lay out a two-country general equilibrium model for a monetary union with financial frictions, as in Bernanke, Gertler and Gilchrist (1999). The model includes an international financial market and a market for consumption goods that are internationally traded. Capital and labor are non-mobile across the two countries. The home country is of size n and the foreign country of size $1-n$. Each economy is composed of households, intermediate good producers, final good producers, entrepreneurs, capital goods producers and domestic financial intermediaries. There is a single monetary authority for the currency union, while fiscal and macroprudential policies are implemented individually by national authorities. To model the international financial market I follow Quint and Rabanal (2014) and I include international financial intermediaries that connect the domestic financial intermediaries of both countries. The model was explained in detail in Chapter 1, that describes the problem of each agent for the home country. The same maximization and minimization problems are applied to the foreign country. Variables and parameters for the foreign country are denoted with superscript $*$. The following sections and subsections contain an explanation of the open economy dimensions and the macroprudential policy related issues.

2.3.1 Households

There is a continuum of households with infinite life. The representative household maximizes his utility function, choosing total consumption, c_t, of foreign or domestic goods, time devoted to work, l_t, and financial assets, deposits, a_t, and government bonds, d_t, both in positive amounts.

Consumption by domestic households is composed by domestic goods and foreign goods in the form of imports. The domestic consumption index follows the form:

$$c_t = \left[(1-\varphi)^{\frac{1}{\zeta}} (c_{H,t})^{\frac{\zeta-1}{\zeta}} + \varphi^{\frac{1}{\zeta}} (c_{F,t})^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}}, \tag{2.1}$$

where $c_{H,t}$ is the consumption of domestic goods and $c_{F,t}$ is the amount of imports. The parameter $\varphi \in [0,1]$ is a measure of the degree of openness and therefore $1-\varphi$ represents the home bias in consumption. The degree of substitutability between domestic and foreign goods is given by $\zeta > 0$. Total consumption expenditures are given by

$$p_t c_t = p_{H,t} c_{H,t} + p_{F,t} c_{F,t}, \tag{2.2}$$

where the home consumer price index, p_t is composed by the price of domestic goods, $p_{H,t}$, and the price of foreign goods, $p_{F,t}$. For simplicity, I assume that the law of one price holds so the prices of the goods produced at the foreign country are the same across countries and so are the prices of the goods produced at the home country.[5] That is, $p_{H,t} = p^*_{H,t}$ and $p_{F,t} = p^*_{F,t}$:

$$p_t = \left[(1-\varphi)(p_{H,t})^{1-\zeta} + \varphi (p_{F,t})^{1-\zeta}\right]^{\frac{1}{1-\zeta}}. \tag{2.3}$$

Households choose their allocations between home and foreign goods maximizing the consumption by domestic households (Equation (2.1)) subject to total expenditures. The demand equations for $c_{H,t}$ and $c_{F,t}$ can be derived from this maximization

[5] As this model represents a monetary union all prices are expressed in the same monetary units.

problem:

$$c_{H,t} = \left(\frac{p_{H,t}}{p_t}\right)^{-\zeta} (1-\varphi)\, c_t, \tag{2.4}$$

and

$$c_{F,t} = \left(\frac{p_{F,t}}{p_t}\right)^{-\zeta} \varphi c_t. \tag{2.5}$$

The same maximization problem applies for the foreign country with a degree of openness of φ^*.

The terms of trade are given by:

$$t_t = \frac{p_{F,t}}{p_{H,t}}. \tag{2.6}$$

This equation implies that an increase of t_t reflects a depreciation of the terms of trade and an increase of the competitiveness of domestically produced goods with respect to the goods produced in the foreign country.

2.3.2 International Financial Intermediary

Following Quint and Rabanal (2014), the model incorporates an intermediary between domestic financial intermediaries of the home country and domestic financial intermediaries of the foreign country: international financial intermediaries. These agents borrow from the country with excess loanable funds to lend them to the country that has a shortage of loanable funds. They pay to the lending country a rate equal to the interest on deposits of that country and receive from the borrowing country a rate equal to the interest on deposits of that other country. Incomplete markets in this model imply that the interest rate differs across countries. Thus, the differential between the deposit interest rates of both countries equals the profits made by international financial intermediaries.[6] This differential, also known as

[6]Schmitt-Grohé and Uribe (2002) propose different alternatives to induce stationarity in a small open economy model with incomplete asset markets. In this line, I introduce an interest rate that is increasing in the level of debt.

country debt premium, is given by

$$R_t - R_t^* = \kappa_t e^{\Omega\left(\frac{B_t}{p_t y} - \frac{B}{py}\right)} - 1. \tag{2.7}$$

For simplicity, as in Quint and Rabanal (2014), I take the home country as the reference so that the debt premium depends on the ratio of real international debt, $\frac{B_t}{p_t}$, to steady state real GDP, y, of the home country. In what follows I will denote real international debt by $\bar{B}_t$ and real private debt by $\bar{b}_t$. If the home country borrows from the international market, $B_t > 0$ and $R_t > R_t^*$. The parameter $\Omega > 0$ denotes the elasticity of the debt premium, and κ_t is a debt premium shock that follows

$$\kappa_t = \rho_\kappa \kappa_{t-1} + \sigma_\kappa \varepsilon_{\kappa,t}, \tag{2.8}$$

where $\rho_\kappa \in [0,1]$ is the persistence parameter; and σ_κ is the volatility of the shock, $\varepsilon_{\kappa,t} \backsim N(0,1)$.

Profits obtained by international financial intermediaries are distributed porportionally across households of both countries. Assuming that $nB_t = -(1-n)B_t^*$, international financial intermediaries receive:

$$\begin{aligned} R_t nB_t - R_t^*(1-n)(-B_t^*) = (R_t - R_t^*)nB_t = \\ R_t - \left[R_t - \kappa_t\left(e^{\Omega\frac{B_t}{p_t y}} - 1\right)\right] nB_t = \\ \kappa_t\left(e^{\Omega\frac{B_t}{p_t y}} - 1\right) nB_t. \end{aligned} \tag{2.9}$$

2.3.3 Fiscal Authority

There is a national fiscal authority (or government) that finances its expenditures via taxes and public debt, according to the following budget constraint:

$$\frac{d_t}{p_t} = g_t + R_{t-1}^d \frac{d_{t-1}}{p_t} - tax_t, \tag{2.10}$$

where d_t denotes current issue of public debt; g_t is government spending. Finally, tax_t denotes tax revenues defined by

$$tax_t = \tau_c c_t + \tau_l w_t l_t + \tau_R \left(R_{t-1} - 1\right) \frac{a_{t-1}}{p_t}. \tag{2.11}$$

As in Fernández Villaverde (2010), I assume that government spending evolves by the following fiscal rule:

$$\widehat{g}_t = \gamma_g \widehat{g}_{t-1} + d_g \frac{d_{t-1}}{p_t y_t} + \sigma_g \varepsilon_{g,t}, \text{ where } \varepsilon_{g,t} \backsim N(0,1), \tag{2.12}$$

and where $\widehat{g}_t$ are the log deviations with respect to the mean of the government spending process; and $d_g \leq 0$ is the sensitivity of government expenditure to changes in the ratio of debt over output, its sign reflects the objective of public debt stabilization. Parameter $\gamma_g \in [0,1]$ is the persistence coefficient and σ_g is the volatility of the government spending shock.

2.3.4 Monetary Authority

The monetary authority or central bank is common for both countries and uses monetary policy to stabilize the monetary union gross inflation rate, Π_t^{MU}, and real output, y_t^{MU}. With that aim, the central bank sets the monetary policy instrument, or interest rate for the union. This analysis takes into account the active/passive definitions introduced by Leeper (1991). Leeper explains that an active policy is the one unconstrained by sovereign debt and a passive policy is the one constrained by current budgetary conditions and active authority actions. I consider the scenario where different national passive fiscal policies are combined with a single active monetary policy that stabilizes inflation at the union level.

Monetary union inflation is given by

$$\Pi_t^{MU} = \frac{p_t^{MU}}{p_{t-1}^{MU}}, \tag{2.13}$$

where

$$p_t^{MU} = (p_t)^n \left(p_t^*\right)^{1-n}, \tag{2.14}$$

and monetary union real output is

$$y_t^{MU} = (y_t)^n \left(y_t^*\right)^{1-n}. \tag{2.15}$$

The central bank follows a standard Taylor Rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\gamma_R} \left(\left(\frac{\Pi_t^{MU}}{\Pi^{MU}}\right)^{\gamma_\Pi} \left(\frac{y_t^{MU}}{y^{MU}}\right)^{\gamma_y}\right)^{(1-\gamma_R)} \exp(\sigma_m \varepsilon_{m,t}), \tag{2.16}$$

where $\gamma_R \in [0,1]$ is the persistence parameter; $\gamma_\Pi \geq 0$ and $\gamma_y \geq 0$ indicate how strong is the response of the interest policy rate to deviations of Π_t^{MU} and y_t^{MU} from their steady states, respectively; and σ_m is the volatility of the monetary policy shock, $\varepsilon_{m,t} \backsim N(0,1)$.

The nominal interest rate is modified through open market operations financed by transfers, T_t and T_t^* for the home and foreign country, respectively.

2.4 Macroprudential policy

In this section, I include a macroprudential authority that sets policies to stabilize the financial system. Through macroprudential policy instruments the amount of loans to be lent to the private financial sector is controlled and private debt volatility is reduced in order to guarantee a more stable cycle.

Therefore, following Quint and Rabanal (2014), I introduce a macroprudential tool that controls the ability to lend of the domestic financial intermediaries in the following way:

$$\frac{1}{\eta_t}(B_t + a_t) = b_t, \tag{2.17}$$

where η_t is a new variable that affects the credit market conditions.

The macroprudential regulation will affect financial variables countercyclically. Higher

values of η_t reflect a tightening macroprudential policy, while lower values reflect an easing macroprudential policy. This macroprudential rule implies that, when the regulation is tightening, domestic financial intermediaries can only lend a fraction of the funds they get from households and from international financial intermediaries. However, in line with Quint and Rabanal (2014), I allow the macroprudential instrument to behave symmetrically and go below one. Thus, when the regulation is easing, the central bank will provide liquidity to domestic financial intermediaries so that they can lend more than the amount of deposits and international funds they hold on their balance sheet.

In line with Quint and Rabanal (2014), I also make η_t dependent on the deviation of credit market conditions, Ψ_t, from their steady state, Ψ, as follows:

$$\eta_t = \left(\frac{\Psi_t}{\Psi}\right)^{\gamma_\eta}, \tag{2.18}$$

where $\gamma_\eta > 0$ reflects how responsive η_t is to the indicator of credit market conditions considered. Notice that macroprudential policies do not affect the steady state since $\eta = 1$ whenever $\Psi_t = \Psi$.

Chapter 1 includes an analysis of the two alternative macroprudential instruments proposed by Quint and Rabanal (2014). They first define Ψ_t as the deviation of the nominal private credit growth and second as the deviation of the private credit-to-GDP ratio.

The results obtained in Chapter 1, for a closed economy, show that macroprudential policy always stabilizes private debt but GDP only when it targets nominal credit growth. Therefore, as my objective is to analyze macroprudential policy as a way of attaining macroeconomic and financial stability, in this chapter I define Ψ_t as the nominal private credit growth. This is consistent with Basel III that states that monitoring excessive credit growth is one of the most important financial indicators that should be consider when implementing macroprudential policy. Therefore,

$$\Psi_t = \frac{\bar{b}_t}{\bar{b}_{t-1}}\Pi_t. \tag{2.19}$$

Thus, the macroprudential instrument becomes tightening when there is an increase in the nominal private credit growth and easing if the latter decreases.

As in Dehmej and Gambacorta (2017), I analyze the case of federal macroprudential policy. When federally-implemented, the macroprudential tool is the same in both countries of the union and it targets aggregate nominal credit growth with a degree of responsiveness of γ_{η}^{MU}, therefore:

$$\eta_t^{MU} = \left(\frac{\Psi_t^{MU}}{\Psi^{MU}} \right)^{\gamma_{\eta}^{MU}}, \tag{2.20}$$

being

$$\Psi_t^{MU} = \frac{\bar{b}_t^{MU}}{\bar{b}_{t-1}^{MU}} \Pi_t^{MU}, \tag{2.21}$$

where $\bar{b}_t^{MU}$ is the aggregate real private debt,

$$\bar{b}_t^{MU} = \left(\bar{b}_t\right)^n \left(\bar{b}_t^*\right)^{1-n}, \tag{2.22}$$

and with Π_t^{MU} denoting the monetary union inflation.

Introducing the macroprudential tool into the zero profit condition of the domestic financial intermediary (a detailed explanation can be found in Chapter 1):

$$\left[1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] R_{t+1}^l b_t + (1-\mu) \int_0^{\varpi_{t+1}} \omega dF\left(\omega, \sigma_{\omega,t}\right) R_{t+1}^k p_{H,t} q_t k_t = s_t R_t \eta_t b_t. \tag{2.23}$$

The following expression for the lending-deposit spread can be derived:

$$\frac{R_{t+1}^l}{R_t} = \frac{s_t \eta_t}{\left[1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] + \frac{(1-\mu)}{\varpi_{t+1}} \int_0^{\varpi_{t+1}} \omega dF\left(\omega, \sigma_{\omega,t}\right)} \tag{2.24}$$

Notice that when the macroprudential policy is tightening the lending-deposit spread increases, while when the macroprudential policy is easing the lending-deposit spread goes down.

The one period interest rate of the loan is set on the contract that the domestic finan-

cial intermediary agrees with the entrepreneur, together with ϖ_{t+1}. The previous expression shows that R^l_{t+1} also depends on the level of η_t for the current period so the macroprudential policy affects the contractual agreement. Therefore, when the macroprudential rule is too restrictive the R^l_{t+1} set in the contract is higher than in the case in which macroprudential policy is relaxed. This ensures that when I introduce macroprudential policy domestic financial intermediaries can still obtain zero profits, paying the same R_t to households and international financial intermediaries because the rate on loans, R^l_{t+1}, increases. Thus, despite macroprudential policy, lending funds in the form of deposits or through an international bond to financial intermediaries is still worth it for households and international intermediaries. Entrepreneurs, however, support a higher cost of debt if they need to borrow when macroprudential policy is tightening and a lower cost of debt if they need to borrow when macroprudential policy is easing. As a consequence private credit is affected not only from the supply side but also from the demand side, which is the goal of the macroprudential authority.

2.5 Aggregation and Equilibrium

Aggregate output in the model is given by

$$y_t = c_{H,t} + \frac{1-n}{n} c^*_{H,t} + i_t + g_t + \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\left(r_t + q_t\left(1-\delta\right)\right) k_{t-1}, \tag{2.25}$$

from the demand side. And the aggregate supply is

$$y_t = \frac{1}{\upsilon_t} e^{z_t} k^{\alpha}_{t-1} l^{1-\alpha}_t, \tag{2.26}$$

being υ_t the inefficiency created by price dispersion that evolves as:

$$\upsilon_t = \theta \left(\frac{\Pi^{\chi}_{H,t-1}}{\Pi_{H,t}}\right)^{-\varepsilon} \upsilon_{t-1} + \left(1-\theta\right)\left(\bar{\Pi}_{H,t}\right)^{-\varepsilon}. \tag{2.27}$$

The net foreign asset position is

$$n\bar{B}_t = nR_{t-1}\frac{\bar{B}_{t-1}}{\Pi_t} + n\frac{p_{F,t}}{p_t}c_{F,t} - (1-n)\frac{p_{H,t}}{p_t}c^*_{H,t}. \tag{2.28}$$

The equilibrium in this model, considering that there is a home country and a foreign country, can be defined as the sequence of quantities $\{c_t,\ c_{H,t},\ c_{F,t},\ l_t,\ a_t,\ k_t,\ i_t,\ b_t,\ B_t,\ c^*_t,\ c^*_{H,t},\ c^*_{F,t},\ l^*_t,\ a^*_t,\ k^*_t,\ i^*_t,\ b^*_t,\ B^*_t\}_{t=0}^{\infty}$; fiscal policy $\{g_t,\ tax_t,\ d_t,\ g^*_t,\ tax^*_t,\ d^*_t\}_{t=0}^{\infty}$; prices $\{p_t,\ p_{H,t},\ p_{F,t},\ r_t,\ w_t,\ q_t,\ p^*_t,\ r^*_t,\ w^*_t,\ q^*_t\}_{t=0}^{\infty}$, and interest rates $\{R^d_t,\ R_t,\ R^k_t,\ R^l_t,\ R^{d*}_t,\ R^*_t,\ R^{k*}_t,\ R^{l*}_t\}_{t=0}^{\infty}$, given exogenous variables $\{z_t,\ \widehat{\sigma}_{\omega,t},\ \widetilde{s}_t,\ \phi_t,\ z^*_t,\ \widehat{\sigma}^*_{\omega,t},\ \widetilde{s}^*_t,\ \phi^*_t,\ \kappa_t\}_{t=0}^{\infty}$, such that:

- optimization problems are satisfied for all agents of both countries in the model; and
- all markets clear, that is, in the case of the home country

$$y_t = c_{H,t} + \frac{1-n}{n}c^*_{H,t} + i_t + g_t + \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\left(r_t + q_t\left(1-\delta\right)\right)k_{t-1},$$

$$y_t = \frac{1}{\upsilon_t}e^{z_t}k^{\alpha}_{t-1}l^{1-\alpha}_t,$$

$$l^s_t = l^d_t,$$

$$nB_t = (1-n)\,B^*_t$$

$$\begin{cases} a_t + B_t = b_t & \text{if macroprudential policy is not included,} \\ \frac{1}{\eta_t}\left(a_t + B_t\right) = b_t & \text{if macroprudential policy is included.} \end{cases}$$

- plus the laws of motion

$$k_t = (1-\delta)k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right)i_t, \text{and}$$

$$\frac{d_t}{p_t} = g_t + R^d_{t-1}\frac{d_{t-1}}{p_t} - tax_t.$$

$$n\bar{B}_t = nR_{t-1}\frac{\bar{B}_{t-1}}{\Pi_t} + n\frac{p_{F,t}}{p_t}c_{F,t} - (1-n)\frac{p_{H,t}}{p_t}c^*_{H,t}.$$

For the foreign country the market clearing is replicated in the same way but using the foreign variables of the model.

2.6 Calibration of the parameters and steady state

Table 2.2 shows the parametrization I use in the model. I calibrate most of the parameters based on Gomes and Seoane (2018), Fernández-Villaverde (2012), Fernández-Villaverde (2010) or Bernanke, Gertler and Gilchrist (1999). All parameters and steady states are the same for both countries except for home country imports and foreign country imports, $\frac{c_F}{y}$ and $\frac{c^*_H}{y^*}$ respectively, and the steady state that result from these values. Also γ_η and γ^*_η depend on the macroprudential scenario considered. Table 2.3 includes a summary of the steady state values that are relevant for the analysis.

Open economy. I assume that both countries are of equal size, $n = 0.5$. Then I set the fraction of imported goods from the foreign country to the home country over GDP to 0.1 and the fraction of imported goods from the home country to the foreign country over foreign GDP to 0.11. Therefore, the home country is a net exporter and the foreign country a net importer in steady state what, taking into account the net foreign asset position implies that international debt is different from 0. The substitutability between domestic and foreign goods is set to $\zeta = 1.5$. The terms of trade, t, are 1 in steady state what means that the price of the goods produced in the home country are the same to the price of the foreign country produced goods. The debt elasticity of the country premium is different to zero to induce stationarity (Schmitt-Grohé and Uribe, 2002), concretely $\Omega = 0.0043$.

Preferences. I set the discount factor to $\beta = 0.999$, being the same for both countries and $\Pi_H = \Pi_F = \Pi = \Pi^* = 1.005$ what imply an average annual real interest rate equal to 0.4%. Habits on consumption are $h = 0.5$, and the Frisch elasticity of labor is $1/\vartheta = 2$. Labor in steady state is $l = \frac{1}{3}$.

Technology. The capital share, α, is set equal to 0.33; capital depreciation rate, δ, equals 8.9% at an annual rate; and capital adjustment costs are such that $S^{"}[1] = 14.477$. The Calvo pricing parameter, θ, is 0.8 what means on average 5 quarters of duration of prices; the degree of indexation to past inflation, χ, equals 0.6; and the elasticity of substitution across goods, $\varepsilon = 8.577$, what implies a markup of around 13% in the goods sector.

Financial variables. I consider monitoring costs, μ, are 15% of the entrepreneur's output; the loan-to-capital ratio is set equal to $\frac{\bar{b}}{k} = \frac{1}{3}$; the average spread on loans s, is 0.25%; the survival rate of entrepreneurs is $\gamma^e = 0.975$ and the annual probability of default is 3%.

Fiscal policy. The steady state values for tax rates are taken from Fernández-Villaverde (2010) and equal to $\tau_l = 0.24$, $\tau_r = 0.42$; government spending-to-GDP ratio equals 20%, and the debt-to-GDP ratio is 60%. Given these values τ_c is determined from the government's budget constraint. Parameter d_g in the fiscal rule is set to -0.01.

Monetary policy. In the analysis below, monetary policy is conducted at the union level. I assume that the response of intervention rate to changes in inflation is $\gamma_{\Pi}(1 - \gamma_R) = 1.5$ what implies that the monetary union authorities have the objective of inflation stabilization, so monetary policy is active.

Macroprudential policy. The macroprudential policy parameters, γ_η and γ_η^*, equal 0 when there is no macroprudential policy in the country considered and are set to 1.75 when macroprudential policy is included.

Shock processes. I consider quite permanent shock processes, therefore, I set autoregressive coefficients equal to 0.95, and standard deviations are taken from the empirical evidence and past literature, as summarized in Table 2.2.

2.7 Impulse Response Functions (IRFs)

This section analyzes the response of the main economic variables of the two-country model to a credit risk shock originated in the home country. In all the scenarios considered the shock is a 1 percent standard deviation increase in private credit risk, $\sigma_{\omega,t}$. Following Leeper's definition, monetary policy is always active in this analysis. According to Leith and Wren-Lewis (2006), to attain a determinate equilibrium in a monetary union where the monetary authority targets inflation, each nation of the union needs to stabilize its public debt through fiscal policy. In line with Leeper (1991), this kind of fiscal policy is passive. This chapter focuses on the use of a government spending rule and leaves aside the tax rule to isolate the effects of the former. In this economy, monetary policy aims at pursuing price stability for the monetary union. Therefore if it leans against the wind to solve financial stability problems it will leave aside its main objective. This implies that a new toolkit needs to be added to the financial stability framework: macroprudential policy.

The scenarios analyzed below compare a version of the model with no macroprudential policy with two other versions implying different macroprudential policy implementations in a monetary union: country-targeted and federal macroprudential measures. A country-targeted macroprudential policy is the one that reacts to national nominal private debt growth. A federally implemented macroprudential policy targets the growth of the aggregate nominal credit. In both scenarios all the countries belonging to the monetary union implement the corresponding macroprudential toolkit, that is, there is always coordination in the use of macroprudential policy[7].

[7]Appendix E includes two alternative country-targeted macroprudential scenarios, named non-coordinated macroprudential scenarios: in one of them the home country is the only one that applies macroprudential policy and in the other macroprudential policy is implemented only by the foreign country. The IRFs for these alternative non coordinated scenarios are plotted in Figure 2.5 and Figure 2.6. The home country is not affected by what the foreign country does, so for the home country the former scenario is equivalent to the case in which both implement macroprudential policy and the latter scenario to the no macroprudential policy case. The foreign country however is more stabilized when the home country applies macroprudential policy than when it is implemented by itself or by both countries at the same time. These results provide a rationale of the incentives that the country not responsible for the risk shock has to free-ride on the macroprudential policy of the other country. Moreover, this is consistent with the findings of Rubio and Carrasco-Gallego

In what follows, I comment on the main differences between the three macroprudential scenarios represented in Figure 2.3 and Figure 2.4: no macroprudential (solid), country-targeted macroprudential (dotted) and federal macroprudential (dashed).

In all the three scenarios, an increase in the credit risk of the home country private sector raises the probability of default of the home country entrepreneurs. Thus, home country lenders toughen the terms of the contract by increasing the interest rate paid on loans (not shown in the figures). This generates a decrease in the demand of private debt that brings down the demand for capital and its price, the Tobin's q, (neither of them shown in the figures). The Tobin's q values the firm's assets, thus the firm's networth in the home country is also reduced. Quint and Rabanal (2014) analyze the effects of a negative credit risk shock that reduces risk in the country where it is originated. They also find that private debt moves inversely with respect to the probability of default.

If there is no macroprudential policy, the effects just described are larger for the financial sector, implying a sharp decrease in private investment and making GDP fall in the home country. This is in line with Christiano et al. (2010), Gomes and Seoane (2018) and Chapter 1 of this dissertation. The fall in investment and private debt in the home country also reduces its demand for international funds (the home country is a net international borrower in the steady state), thus putting down the risk premium on international debt. This implies a reduction in the differential between the deposit rates of both countries. As a consequence of the home country recession, in the absence of macroprudential policy, there is a capital flight from the latter to the foreign country. The capital flight generates higher levels of foreign private debt and foreign investment, increasing foreign output.

Due to the fall of public revenues, public debt rises as output goes down in the home country, in the no macroprudential scenario. The opposite happens in the foreign country. Therefore, in the home country lower private debt depresses investment

(2016) about the stabilization benefits for a country that does not implement macroprudential policy when the other countries of the same monetary union implement it. However, my results show that, unlike what Rubio and Carrasco-Gallego (2016) find, the country where the shock is originated cannot benefit from the other country's macroprudential policies. The main reason for this difference in their results is that they consider that all countries are hit by symmetric shocks.

and output so tax collection falls pushing upwards public debt, that is, generating the private-public debt channel. In the foreign country, as a consequence of the home country credit risk shock, entrepreneurs expand their private investment resulting in a rise of output and private leverage. Foreign labor goes up increasing the collection of taxes during the first periods that immediately follow the shock. It is remarkable that around the fifth period after the shock, the collection of foreign taxes starts to decrease as a consequence of a fall in the return on deposits. The return on deposits is directly related to the policy rate that, in this scenario, goes down to stabilize the monetary union aggregate inflation. Both the rise of tax revenues and inflation (debt deflation channel) bring down foreign public debt immediately after the shock, activating the private-public debt channel also in the foreign country. Thus, for the model and calibration used in this chapter, the private-public debt channel operates in both countries when macroprudential policy is not implemented.

However, macroprudential policy changes significantly the effects of the credit risk shock. As mentioned in Section 2.4, the analysis is focused on the implementation of a macroprudential tool, η_t, that reacts to nominal credit growth. In the home country, after the credit risk shock that brings down private leveraging, a countercyclical macroprudential policy eases credit conditions with respect to the no macroprudential scenario, alleviating the fall of private debt. Therefore, the decrease of investment in response to the shock is smoothed. This is passed on to output and, thus, to public revenues. In the foreign country however, very different effects arise from the application of either national or federal macroprudential policies, which are discussed below.

2.7.1 Implementation of national macroprudential policy

When macroprudential policy targets the growth of national nominal credit, the private-public debt channel is offset and macroeconomic and financial stabilization is achieved for both countries (see the volatilities in Table 2.4 and correlations in Table 2.5). A weaker fall of private debt in the home country together with the improvement of the main financial variables brings the home country output to

a more stable path, with respect to the no macroprudential scenario. Foreign private debt still increases smoothly in this scenario but is almost isolated from the effects of the shock. This time, the fall of foreign networth and Tobin's q makes foreign investment fall down slightly so foreign output also experiences a smooth decrease. Foreign output is also more stable due to a foreign macroprudential policy that restricts credit conditions and refrains investment and GDP growth. In both countries, automatic stabilizers transfer the effect of output stabilization to public debt. Moreover, there is a debt deflation effect by which as inflation goes up real public debt decreases in the home country and as inflation falls real public debt rises in the foreign country. Therefore, by stabilizing private and public debt at the same time, the country-targeted macroprudential policy offsets the private-public debt channel in both countries.

Nevertheless, there is an additional channel that contributes to stabilize home country and foreign GDP when the macroprudential policy is country-targeted: the open economy channel. Home country inflation increases and foreign inflation goes down so the terms of trade decrease, that is, foreign goods are more competitive than home country goods because their relative price is lower. Then, the home country increases imports and decreases exports (i.e, net exports go down). This is consistent with the expenditure-switching effect to which some traditional open macro models refer (see Engel, 2003; Galí and Monacelli, 2003; or Corsetti, 2007). The expenditure switching effect compensates partially the effects of investment on output in both countries, contributing to macroeconomic stabilization. Recent literature on macroprudential policy also finds that the introduction of the latter reduces macroeconomic and financial volatility (see for example Quint and Rabanal, 2014; Rubio and Carrasco-Gallego, 2016; or Dehmej and Gambacorta, 2017).

2.7.2 Implementation of federal macroprudential policy

The above mentioned open economy channel explains why, when countries implement a federal macroprudential policy, the home country experiences strong macroeconomic and weaker financial stabilization. At the same time, this channel is

responsible for the foreign country destabilization in terms of output, public and private debt (see Table 2.4 for the main variables' volatility). It is worth emphasizing that, in this scenario, stabilization in the home country is not due to the cancellation of the private-public debt channel as the latter remains at work under federal macroprudential policy. As this kind of macroprudential policy does not target national variables directly, the decrease of home country private debt after the shock is smoothed but not as much as in the national macroprudential case. Thus, the private debt behavior fails to increase investment in the home country although the latter falls by less than in the no macroprudential situation. Patently, the effects of federal macroprudential policy on national variables are not as countercyclical as when a national macroprudential policy is in place. Instead, it is possible to observe how the foreign macroprudential tool reacts much more than what its economy needs. This federal policy encourages significantly foreign private debt, what is translated into more foreign investment and a sharp growth of foreign GDP. Table 2.4 shows how foreign output is destabilized with this kind of federal policy.

As mentioned before, in the federal macroprudential scenario, there is a different channel that contributes to output stabilization in the home country: the open economy channel. Foreign inflation goes up and home country inflation decreases what raises the terms of trade. The open economy channel appears because the rise of the terms of trade increases home country net exports. Then, this channel compensates the effect of the home country investment fall, moderating the path of the home country GDP. The role of proportional taxes in this federal scenario is crucial for both countries, being the main responsible for the private-public debt channel. In the home country, tax revenues go down following a similar path to output so public debt rises moderately. So government debt increases as private debt falls, thus the channel is still at work. In the foreign country, the rise of GDP increases tax revenues what provokes a deep decrease of public debt. As foreign private debt grows with this federal policy and public debt goes down the private-public debt channel also operates here.

2.7.3 Volatility and correlations

These results about stabilization are confirmed in Table 2.4. The correlation between the private debt-to GDP ratio and the public debt-to-GDP ratio[8] (see Table 2.5) suggests that the national macroprudential tool is the only one that offsets the private-public debt channel. It can also be observed that the negative correlation between private and public debt does not disappear when a federal macroprudential policy is implemented. To summarize, the main reason for these results is that country-targeted macroprudential policy inverts the response of public debt after a financial shock in the home country while when it is federal it only manages to smooth it.

Consequently, there is a trade-off between stabilizing considerably the home country's GDP, which is the most destabilized after the shock, and stabilizing the foreign country's GDP. The country-targeted macroprudential scenario delivers financial and macroeconomic stability for both countries by offsetting the private-public debt channel. Stabilization in the foreign country is significant due to the open economy channel. Dehmej and Gambacorta (2017) find more appropriate, in terms of optimality and stability, the implementation of macroprudential policies that target national variables. They base this argument on the fact that national macroprudential policies can neutralize the effects of asymmetric shocks while federal macroprudential policies cannot. My analysis also finds some stabilization advantages of implementing federal macroprudential policy. The latter generates an alternative channel for attaining macroeconomic stability in the home country, the open economy channel, but at the cost of destabilizing the foreign country. However, I also find that national macroprudential policy implementation is more appropriate given that it targets each country's specific needs.

Comparing these results to the ones obtained for a closed economy (see Chapter 1) it is possible to appreciate a more persistent response of output to a credit risk shock when macroprudential policy is implemented. The reason is the open economy

[8] I focus on these ratios to analyze a measure that is similar to the data that was collected in the empirical analysis of this chapter.

channel generated by the international goods market, which I include in this model. When macroprudential policy is used, home country inflation falls making the price of home goods more competitive relative to that of foreign goods. Then, the home country increases its net exports what contributes to a smoother fall in GDP.

Another interesting result from this analysis is that macroprudential policy, no matter how it is implemented, contributes to the monetary policy role of inflation stabilization and requires smoother responses of the policy rate. This result is also obtained by Quint and Rabanal (2014), as they conclude that macroprudential policy "lends a hand" to monetary policy. As a consequence of macroprudential policy implementation, inflation increases and so does the policy rate. Then, independently of the effects that macroprudential policy has on net exports, there is a fall in total consumption in both countries because the rise in the interest rate induces consumers to delay consumption.

2.8 Robustness analysis

The analysis carried out so far assumes that the economy is mostly affected by a credit risk shock, that seems to have dominated the years of the financial recession that started in 2007. Nevertheless, the economy can be hit by a variety of shocks so the role of macroprudential policies must be analyzed outside the framework of credit risk shocks, to evaluate its effectiveness under other possible scenarios.

In this section, I extend the analysis by looking at the stabilization properties of macroprudential policy in the event of alternative asymmetric shocks other than the credit risk shock. To that end, I consider that the home country is hit by either a spread shock, a preference shock or a technology shock.[9]

In all the three cases, macroprudential policies attain macroeconomic stabilization for the country that suffers the shock but macroeconomic destabilization for the for-

[9]Notice that to make the analysis more comparable I consider a magnitude for each shock that leads to the same volatility of the home country GDP in the no macroprudential scenario, $\sigma(GDP) = 0.0174$, the volatility implied by a credit risk shock with a standard deviation of 0.560 as estimated by Gomes and Seoane (2018).

eign country. After a spread shock, the home country private debt is also stabilized when macroprudential policy is introduced, no matter how it is designed. The financial sector of the foreign country is stabilized when macroprudential policy targets national variables while it is destabilized when macroprudential measures target the average union variables. In the event of a preference shock, the home country attains more financial stability with macroprudential policy while the foreign country is financially destabilized with national macroprudential policy and financially stabilized with federal macroprudential policy. Finally, when the home country is hit by a technology shock, the financial sector of the home country is destabilized with macroprudential policy but, this time, macroprudential measures stabilize the private debt of the foreign country. It is worth mentioning that federally-implemented macroprudential policy always results in a more volatile scenario in both countries than the country-targeted macroprudential policy.

Tables 2.6, 2.7 and 2.8 contain the volatilities of the main economic variables for each shock explained above and the correlations between private and public debt. The tables show that after a spread shock, the private-public debt channel arises in both countries and macroprudential policy only manages to eliminate it in the foreign country. In the event of a technology shock, the channel, present in the home country, is offset when macroprudential policy is implemented nationally. Finally, when the economy is hit by a preference shock originated in the home country, the private-public debt channel appears in the foreign country and is eliminated with any kind of macroprudential policy.

As a conclusion, and in line with previous literature (Angelini et al., 2012 or Quint and Rabanal, 2014), stabilization depends on the shock that hits the economy.

2.9 Conclusion

This chapter considers the implementation of macroprudential policy in a two-country model for a monetary union to complement fiscal policy when monetary policy cannot be used at the national level. With that aim, I compare two al-

ternative ways of implementing macroprudential policy in a monetary union: a country-targeted tool versus a federal tool.

There is a private-public debt channel that destabilizes the economy after a credit risk shock as in Chapter 1. This analysis shows how the cancellation of this channel (through the implementation macroprudential policy) can help stabilize the economy of the home country and the foreign country. However, there is an additional channel that is crucial in this monetary union model: the open economy channel. This channel can contribute to either macroeconomic stabilization or destabilization, depending on how macroprudential policy is designed.

When macroprudential policy targets national financial variables, the private-public debt channel is offset so both countries in the union reach more financial and macroeconomic stabilization than in the no macroprudential case. The federal macroprudential scenario maintains at work the private-public debt channel in both countries. The reason is that public debt increases in the home country and decreases in the foreign country, while private debts perform the opposite paths. However, due to the open economy channel, this macroprudential scenario is the one that brings the greatest macroeconomic stability for the home country, although at the same time, the home country private debt is not as stable as in the national macroprudential case. The destabilization of the foreign country in the federal macroprudential scenario arises from the sharp increase of foreign private debt after the shock, consequence of a foreign easing macroprudential policy.

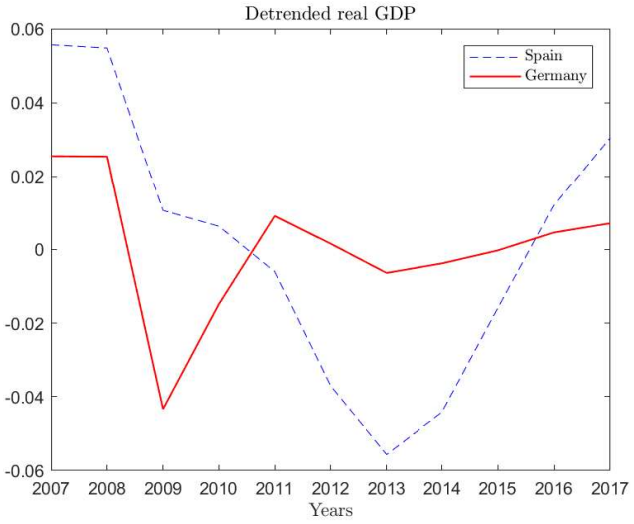
Therefore, in this model, when federal macroprudential policies are implemented, the country responsible for the credit risk shock attains the greatest macroeconomic stability, at the cost of destabilizing the foreign country. On the other hand, national macroprudential policies bring lower levels of macroeconomic stability to the home country but it also provides with macroeconomic stability to the country not responsible for the shock that suffers the effects of its neighbor's behavior.

Macroprudential policy can either reduce or support credit growth, but, as explained by Cerutti et al. (2015), they work better in booms, i.e. constraining credit. But

these measures are also operative in busts, limiting declines in credit. This implies that macroprudential instruments may need to react with a different intensity to encourage or limit credit. In line with this, an interesting analysis left for future research is the implementation of a state-contingent macroprudential policy that could adapt its degree of responsiveness to financial indicators, depending on the phase of the cycle.

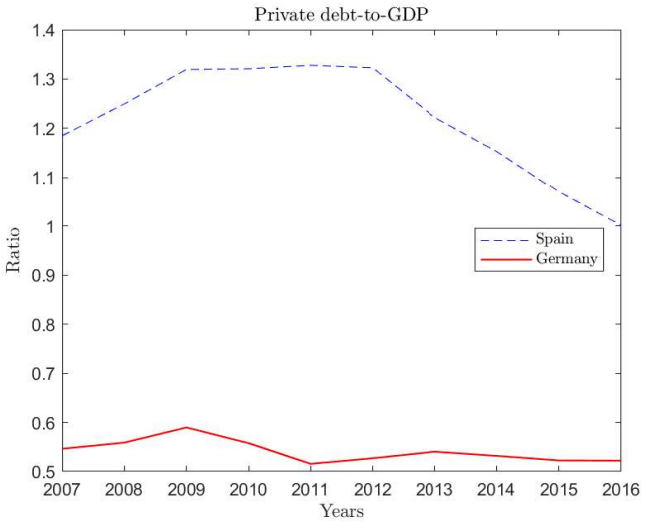
Figures

Figure 2.1: GDP recovery paths in Germany and Spain for period 2007-2017



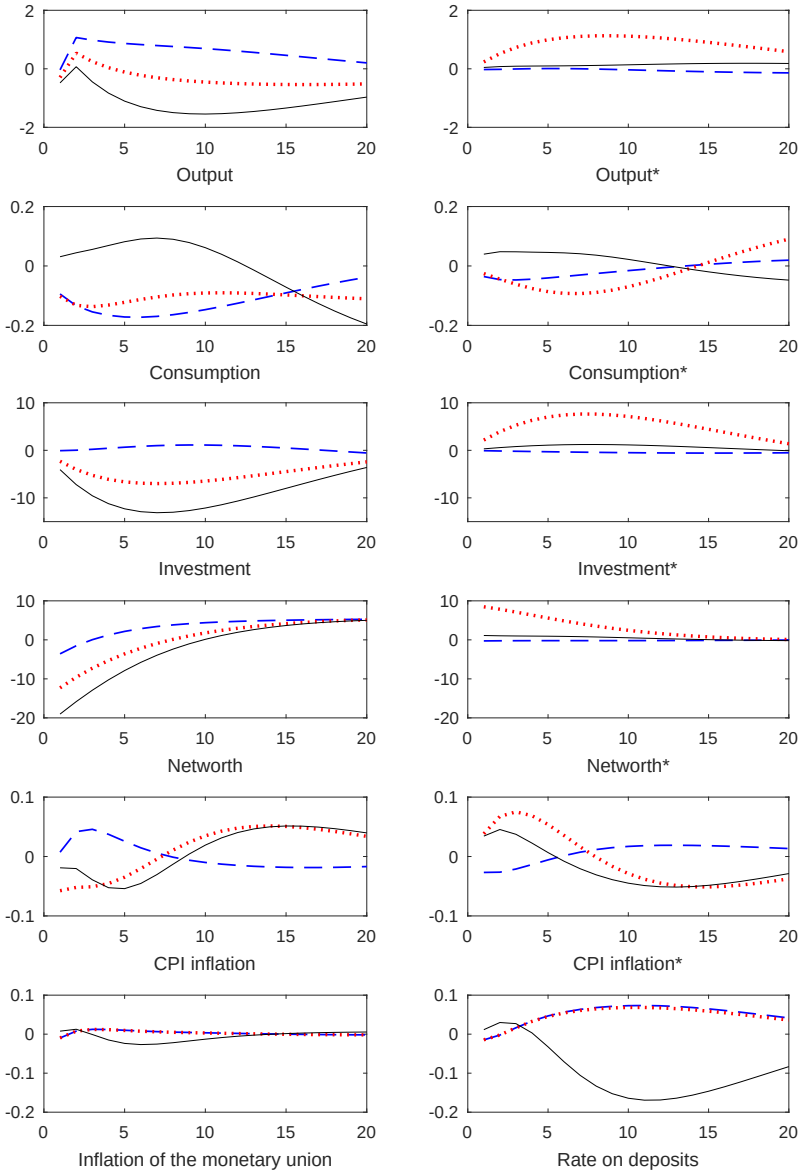
Note: The series plotted in this graph is the real GDP series detrended through the Hodrick Prescott filter.

Figure 2.2: Private debt in Germany and Spain for period 2007-2017



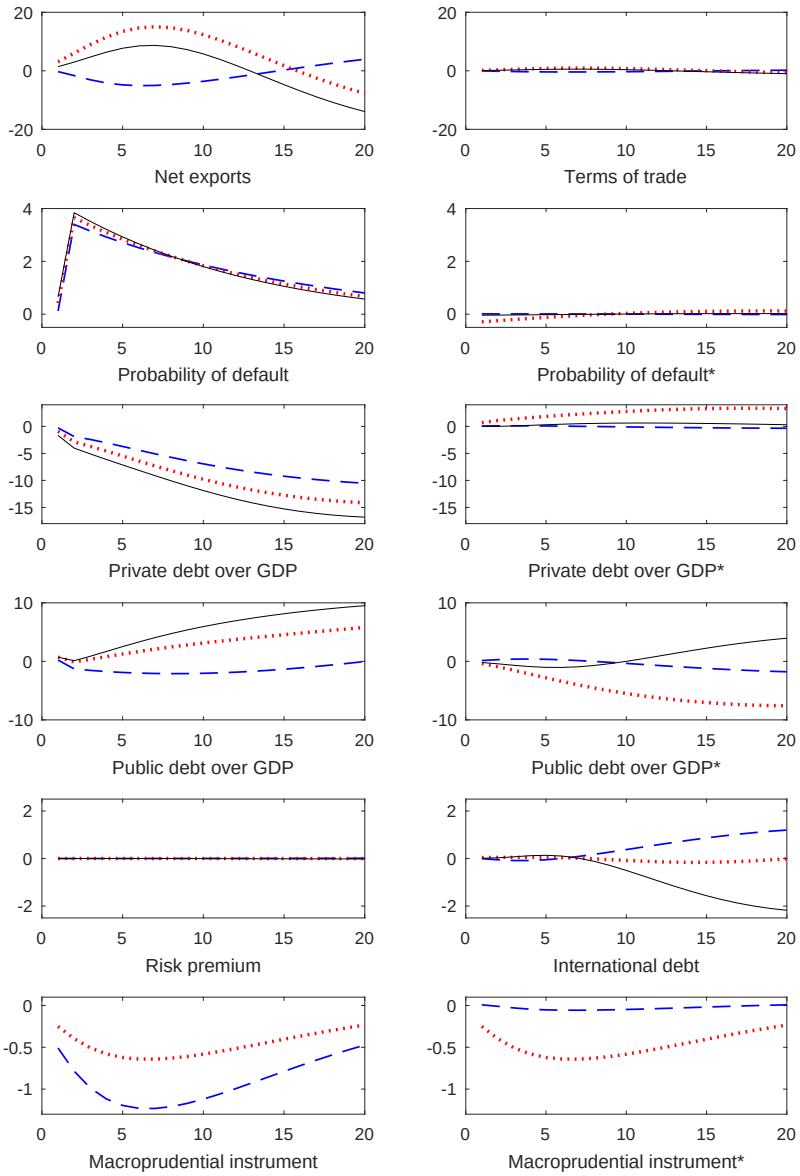
Note: The series plotted in this graph is the real credit to the private non financial sector-to-real GDP ratio.

Figure 2.3: Impulse response functions to a 1 standard deviation rise in credit risk.



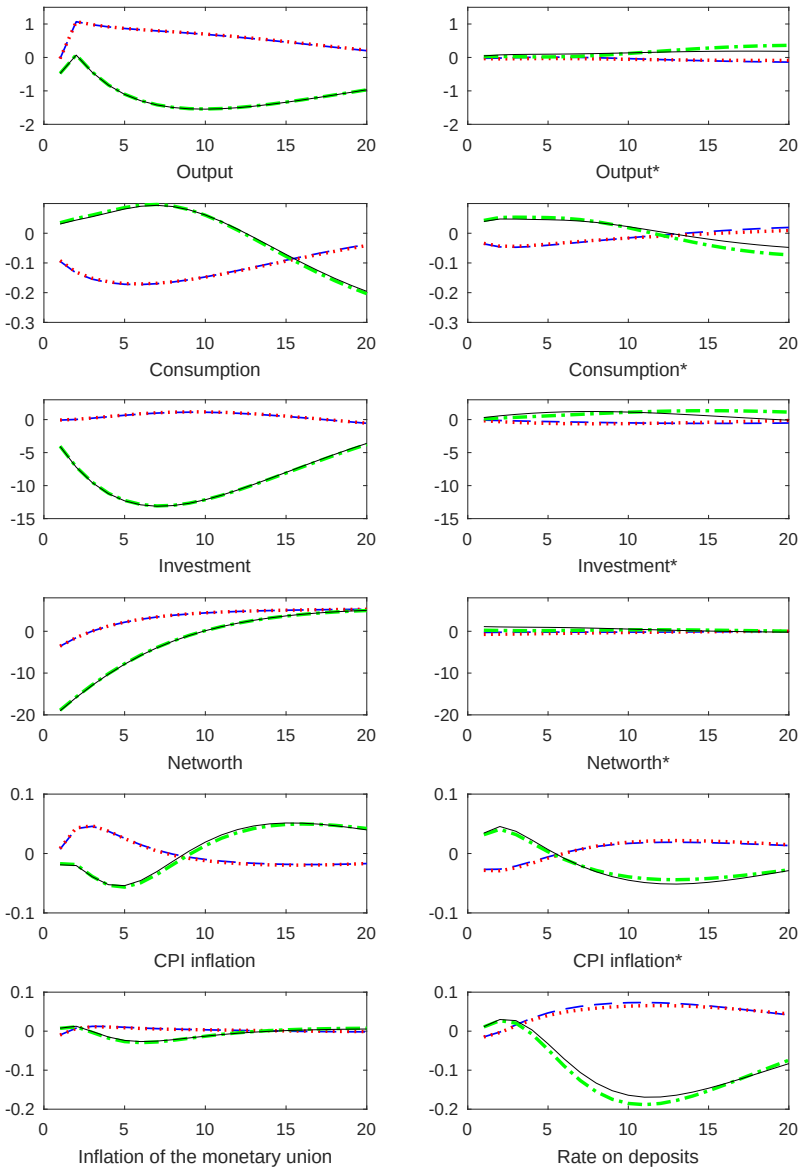
Note: The dashed line represents the country-targeted macroprudential scenario, the dotted line the federally implemented macroprudential scenario and the solid line the no macroprudential scenario. Variables are expressed in percentage points of deviations from steady state. Except for the last row, home variables are in the left column and foreign variables in the right column.

Figure 2.4: Impulse response functions to a 1 standard deviation rise in credit risk.



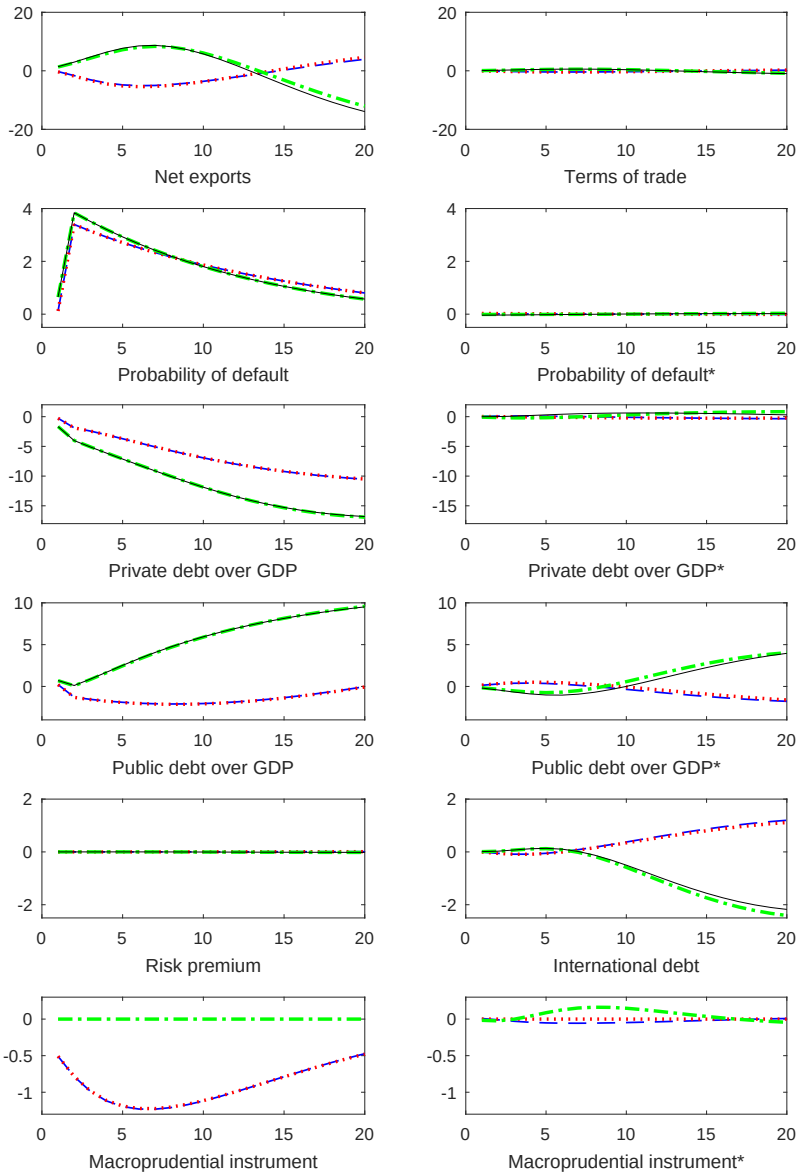
Note: The dashed line represents the country-targeted macroprudential scenario, the dotted line the federally implemented macroprudential scenario and the solid line the no macroprudential scenario. Variables are expressed in percentage points of deviations from steady state. Home variables are in the left column and foreign variables in the right column in the second, third and fifth rows.

Figure 2.5: Impulse response functions to a 1 standard deviation rise in credit risk.



Note: The dashed line represents the country-targeted macroprudential scenario in which both countries apply the instrument, the dotted line the Home country macroprudential scenario, the dash-dotted line the Foreign country macroprudential scenario and the solid line the no macroprudential scenario. Variables are expressed in percentage points of deviations from steady state. Except for the last row, home variables are in the left column and foreign variables in the right column.

Figure 2.6: Impulse response functions to a 1 standard deviation rise in credit risk.



Note: The dashed line represents the country-targeted macroprudential scenario in which both countries apply the instrument, the dotted line the Home country macroprudential scenario, the dash-dotted line the Foreign country macroprudential scenario and the solid line the no macroprudential scenario. Variables are expressed in percentage points of deviations from steady state. Home variables are in the left column and foreign variables in the right column in the second, third and fifth rows.

Tables

Table 2.2: Calibration of the parameters and steady states for Chapter 2

Parameter	**Description**	**Value**	**Source**
β	Discount factor	0.999	Fernández-Villaverde (2010)
h	Consumption habits	0.5	Fernández-Villaverde (2010)
n	Size of the home country	0.5	Faia (2001)
$\frac{c_F}{y}$	Imports from the foreign country-to-GDP	0.1	Own calibration to obtain a ratio $\frac{\bar{B}}{y} = 1.88$
$\frac{c_H^*}{y^*}$	Exports to the foreign country-to-GDP	0.11	Own calibration to obtain a ratio $\frac{\bar{B}}{y} = 1.88$
ζ	Substitutability between domestic and foreign goods	1.5	Faia (2001)
Ω	Debt elasticity of the country premium	0.0043	Quint and Rabanal (2014)
t	Steady state value for the terms of trade	1	Faia (2001)
ϑ	Frisch elasticity of labor	0.5	Fernández-Villaverde (2010)
α	Capital share of the intermediate production function	0.33	Fernández-Villaverde (2012)
δ	Capital depreciation rate	0.023	Fernández-Villaverde (2012)
θ	Calvo pricing parameter	0.8	Fernández-Villaverde (2010)
ε	Elasticity of substitution across goods	8.577	Fernández-Villaverde (2012)
χ	Degree of indexation	0.6	Fernández-Villaverde (2010)
$pdef$	Annual probability of default	0.03	Bernanke et al. (1999)

Parameter	**Description**	**Value**	**Source**
μ	Bankruptcy costs	0.15	Fernández-Villaverde (2012)
$s = s^*$	Average spread	1.0025	Fernández-Villaverde (2012)
$\bar{\gamma}^e = \bar{\gamma}^{e*}$	Entrepreneurs exit coefficient	3.67	Fernández-Villaverde (2010)
$\tau_l = \tau_l^*$	Steady state of labor income tax rate	0.24	Fernández-Villaverde (2010)
$\tau_r = \tau_r^*$	Steady state of capital income tax rate	0.42	Own calibration to obtain a ratio $\frac{\bar{B}}{y}$ of 1.88
$\Pi = \Pi^* = \Pi_H = \Pi_F$	Target gross inflation	1.005	Fernández-Villaverde (2010)
$l = l^*$	Time devoted to work	1/3	Fernández-Villaverde (2010)
$q = q^*$	Tobin's q. Price of capital	1	Fernández-Villaverde (2010)
R^d	Steady state of interest rate on home public debt	$\frac{\Pi}{\beta}$	Fernández-Villaverde (2010)
R	Steady state of interest rate on home deposits	$\frac{R^d - 1}{1 - \tau_R} + 1$	Fernández-Villaverde (2010)
R^{d*}	Steady state of interest rate on foreign public debt	$\frac{\Pi^*}{\beta}$	Fernández-Villaverde (2010)
R^*	Steady state of interest rate on foreign deposits	$\frac{R^{d*} - 1}{1 - \tau_R^*} + 1$	Fernández-Villaverde (2010)
$\frac{\bar{b}}{k} = \frac{\bar{b}^*}{k^*}$	Loan-to-capital ratio	1/3	Fernández-Villaverde (2010)
$\frac{g}{y} = \frac{g^*}{y^*}$	Government expenditure-to-GDP ratio	0.2	Gomes and Seoane (2018)
$\frac{d}{y} = \frac{d^*}{y^*}$	Public debt-to-GDP ratio	0.6	Gomes and Seoane (2018)

Parameter	Description	Value	Source
$S^{"}$ [1]	Capital adjustment costs	14.477	Fernández-Villaverde (2012)
ρ_{ϕ}	Persistence of preference shock	0.95	Fernández-Villaverde (2012)
σ_{ϕ}	Volatility of preference shock	0.143	Own calibration
ρ_s	Persistence of spread shock	0.95	Fernández-Villaverde (2012)
σ_s	Volatility of spread shock	4.205	Own calibration
γ_g	Persistence parameter of government spending shock	0.95	Fernández-Villaverde (2012)
σ_g	Volatility of government spending shock	0.007	Gomes and Seoane (2018)
ρ_z	Persistence of technology shock	0.95	Fernández-Villaverde (2012)
σ_z	Volatility of technology shock	0.031	Own calibration
ρ_{σ}	Persistence of credit risk shock	0.95	Fernández-Villaverde (2012)
η_{σ}	Volatility of credit risk shock	0.560	Gomes and Seoane (2018)
γ_R	Persistence of monetary policy shock	0.95	Fernández-Villaverde (2012)
σ_m	Volatility of monetary policy shock	0.003	Gomes and Seoane (2018)
$\gamma_{\Pi}(1-\gamma_R)$	Response of intervention rate to changes in inflation	1.5	Fernández-Villaverde (2012)
d_g	Response of government spending to changes in public debt	-0.01	Own calibration
d_g^*	Response of foreign government spending to changes in foreign public debt	-0.01	Own calibration

Parameter	**Description**	**Value**	**Source**
$\gamma_\eta = \gamma_\eta^*$	Response of macroprudential tool to changes in credit market conditions	0 or 1.75	Own calibration
$\eta = \eta^*$	Steady state value of macroprudential instrument	1	Quint and Rabanal (2014)

Table 2.3: Main steady state values

Description	Home country	Foreign country
Imports-to-GDP ratio, $\frac{c_F}{y}$ or $\frac{c_H^*}{y^*}$	0.10	0.11
Fraction of consumption produced in the other country, φ	0.17	0.18
International debt-to-GDP ratio, $\frac{\bar{B}}{y}$	1.88	-1.88
Private consumption-to-GDP ratio, $\frac{c}{y}$	0.60	0.62
Private investment-to-GDP ratio, $\frac{i}{y}$	0.18	0.18
Public spending-to-GDP ratio, $\frac{g}{y}$	0.2	0.2
Tax rate on capital, τ_r	0.42	0.42
Tax rate on labor, τ_l	0.24	0.24
Tax rate on consumption, τ_c	0.09	0.06

Note: These values confirm that the home country is a net borrower and the foreign country a net lender in steady state. Moreover, the home country is a net exporter while the foreign country is the net importer.

Table 2.4: Standard deviations for alternative macroprudential implementations under a credit risk shock.

Variable	No macroprudential tool	Country-targeted acroprudential	Federal macroprudential
Home country			
Output	0.0174	0.0140	0.0090
Private debt	0.0806	0.0457	0.0666
Public debt	0.0424	0.0298	0.0203
Foreign country			
Output$*$	0.0013	0.0011	0.0129
Private debt$*$	0.0077	0.0032	0.0213
Public debt$*$	0.0393	0.0153	0.0407

Note: These results are the standard deviations to a standard deviation credit risk shock with $\eta_\sigma = 0.560$

Table 2.5: Correlation between public and private debt for alternative macroprudential implementations under a credit risk shock.

Variable	No macroprudential tool	Country-targeted acroprudential	Federal macroprudential
Home country	-0.8135	0.7757	-0.7262
Foreign country	-0.3539	0.9499	-0.8928

Note: These results are the correlations to a standard deviation credit risk shock with $\eta_\sigma = 0.560$

Table 2.6: Robustness analysis. Second order moments in the event of a spread shock.

Variable	No macroprudential tool	Country-targeted acroprudential	Federal macroprudential
Home country			
$\sigma(Output)$	0.0174	0.0082	0.0131
$\sigma(Privatedebt)$	0.0218	0.0106	0.0164
$\sigma(Publicdebt)$	0.0417	0.0204	0.0356
$\rho(\frac{B}{Y}, \frac{D}{Y})$	-0.4500	-0.8473	-0.7261
Foreign country			
$\sigma(Output*)$	0.0012	0.0013	0.0042
$\sigma(Privatedebt*)$	0.0066	0.0038	0.0112
$\sigma(Publicdebt*)$	0.0346	0.0162	0.0270
$\rho(\frac{B*}{Y*}, \frac{D*}{Y*})$	-0.1165	0.8991	0.4151

Note: These results are the second order moments to a standard deviation spread shock with $\sigma_s = 4.140$.

Table 2.7: Robustness analysis. Second order moments in the event of a preference shock.

Variable	No macroprudential tool	Country-targeted acroprudential	Federal macroprudential
Home country			
$\sigma(Output)$	0.0174	0.0146	0.0150
$\sigma(Privatedebt)$	0.0513	0.0440	0.0470
$\sigma(Publicdebt)$	0.0799	0.0917	0.0839
$\rho(\frac{B}{Y}, \frac{D}{Y})$	0.9252	0.9888	0.9502
Foreign country			
$\sigma(Output*)$	0.0054	0.0081	0.0105
$\sigma(Privatedebt*)$	0.0078	0.0088	0.0071
$\sigma(Publicdebt*)$	0.0699	0.0856	0.0931
$\rho(\frac{B*}{Y*}, \frac{D*}{Y*})$	-0.1769	0.9637	0.7777

Note: These results are the second order moments to a standard deviation preference shock with $\sigma_\phi = 0.156$.

Table 2.8: Robustness analysis. Second order moments in the event of a technology shock.

Variable	No macroprudential tool	Country-targeted acroprudential	Federal macroprudential
Home country			
$\sigma(Output)$	0.0173	0.0137	0.0150
$\sigma(Privatedebt)$	0.0083	0.0089	0.0091
$\sigma(Publicdebt)$	0.0285	0.0257	0.0266
$\rho(\frac{B}{Y}, \frac{D}{Y})$	-0.1673	0.0025	-0.2326
Foreign country			
$\sigma(Output*)$	0.0014	0.0020	0.0029
$\sigma(Privatedebt*)$	0.0060	0.0051	0.0054
$\sigma(Publicdebt*)$	0.0282	0.0332	0.0351
$\rho(\frac{B*}{Y*}, \frac{D*}{Y*})$	0.2137	0.8922	0.7305

Note: These results are the second order moments to a standard deviation technology shock with $\sigma_z = 0.0341$.

Chapter 3

Optimal macroprudential and fiscal policy in a monetary union

3.1 Introduction

The growing interest in optimal macroprudential policy characterizes much of the literature that followed the 2007 world financial recession. The reason is that, after the devastating consequences that the crisis brought to some countries, financial system stability is an issue of current concern. As the 2013 Recommendations of the European Systemic Risk Board (ESRB/2013/1) declare, the safeguard of the stability in the financial system is the ultimate objective of macroprudential policy.

In the context of the European Monetary Union, the Euro Area's experience has shown that a single monetary policy does not manage to stabilize each economy in the union. Thus, authors usually focus their attention on the combination of the optimal monetary policy, set at the union level, and the optimal macroprudential policies. The relevance of the new policy lies on the fact that while monetary policy targets price stability, macroprudential measures might pursue financial stability, which determines the whole economy stability.

However, it is the case that supranational authorities, through monetary policy, address the union-wide stability without taking into account each member's national

economic interests. Sometimes the union's objectives are in conflict with the goals pursued by the national policies, such as fiscal policy. Therefore, I shed light on the interaction between optimal fiscal and optimal macroprudential measures, analyzing the desirabibility to coordinate their objectives, in countries belonging to a monetary union.

The contribution of this chapter is twofold. First, I study the role of optimal macroprudential policy in a monetary union with financial frictions and proportional taxes. In this monetary union, stabilization cannot be attained by the traditional policy mix (fiscal and monetary policies), so I analyze what macroprudential strategies should be followed by policymakers depending on different objectives. On the one hand, I evaluate optimal macroprudential policy as the one that minimizes a specific loss function established by the authorities. On the other hand, I provide results of the welfare gains that each optimal macroprudential policy might attain with respect to a no macroprudential policy scenario.

Second, I analyze the interaction of optimal national macroprudential and fiscal policies in countries of a monetary union hit by asymmetric shocks where there is a common monetary policy. The study in Chapter 1 shows that, after a credit risk shock, a negative correlation arises between private and public leverage. They call in a *private-public debt channel* which implies a trade off between private and public debt stability. The authors find that in order to stabilize the economy, the mechanism needs to be offset and both variables stabilized at the same time. This motivates the analysis of the combination of optimal fiscal and optimal macroprudential policy in this research: optimal fiscal policy focuses on public debt stability, while optimal macroprudential policy focuses on private debt stability. Public debt stability is attained due to national fiscal policies that aimed at controlling the government budget. Private debt stability is the goal of a macroprudential instrument that controls the nominal credit growth.

I evaluate this interaction by obtaining the optimal value of the fiscal and macroprudential parameters in the model, that is, the degree of responsiveness with which fiscal and macroprudential rules should react to their corresponding target variables,

in order to minimize different loss functions. Again, this analysis is complemented with the assessment of the welfare gains that each optimal policy rule computed entails with respect to a baseline scenario. To characterize the union's monetary policy, I introduce an active monetary policy in the spirit of Leeper (1991). This implies that fiscal policy is passive in order to ensure a determinate equilibrium of the model, that is, again following Leeper (1991), I use a fiscal rule in charge of public budget stability.

My study also sheds light on the differences between national and federal macroprudential policy implementation. The former consists of a scenario with national macroprudential rules that react to domestic financial indicators. Federal macroprudential implementation, by contrast, is represented by a scenario in which a supranational authority sets a common macroprudential rule for both countries. Chapter 2 shows that a federal macroprudential policy, reacting with a specific intensity to aggregate variables, entails destabilization for the foreign country. The reason is that the latter has to bear the costs of stabilizing the home country under this scenario. The aim of the present chapter is to undertake an optimal policy analysis, so the federal scenario that targets union-wide aggregate credit conditions as in Chapter 2 or Demej and Gambacorta (2017), seems inappropriate to the foreign country. Therefore, in this analysis, the federal macroprudential policy reacts to the financial indicator of each country with different degrees of responsiveness.

To these aims, I build a two country model so that one country represents the side of the union suffering the shock (hereinafter home country) and the other country represents the side that suffers the effects of the shock originated abroad (hereinafter foreign country), both of equal size. The home country is a net international borrower that represents the periphery and the foreign country is a net international lender representing the core.[1]

I perform the analysis for a variety of shocks originating in the home country to compare different optimal macroprudential scenarios with a baseline case in which

[1] This setting represents the Euro Area case and is in line with Bordo (2014) who explains that TARGET liabilities have increased in countries like Greece, Ireland, Portugal, and Spain (GIPS), since 2007, while TARGET assets have increased in countries like Germany.

macroprudential policy is not implemented.

I introduce macroprudential policy as a variable that monitors the amount of loans to the private sector and reacts to steady state deviations of nominal credit growth. This is consistent with Basel III that states that the broad macroprudential goal is to prevent the financial system from excessive credit growth. Although the ESRB/2013/1 refers to the macroprudential authority as a national authority, this research also considers the macroprudential authority as a federal institution to evaluate the divergences between macroprudential policy at the national and at the union level. This follows other studies such as Rubio (2014) and Dehmej and Gambacorta (2017), that also analyze national and federal implementations of macroprudential policy in a monetary union.

The optimal policy might pursue very diverse objectives that could even require opposite strategies. This chapter studies an optimal policy mix focused on volatility reduction. Then it provides information on the welfare gains or losses of each optimal policy scenario compared to the baseline no macroprudential scenario, as in Rubio and Carrasco-Gallego (2014). The optimal macroprudential policy implementation should be analyzed with respect to the specific objective that authorities are willing to achieve (either stabilization or welfare maximization). In particular, I use macroprudential policy as a tool that pursues financial stability by reacting to changes in nominal credit growth.

The results can be classified in terms of both the authorities' objective and the shock that hits the economy. First, I show that the introduction of macroprudential policy, as modeled in this analysis, contributes to the stability of the main economic and financial variables under the different shocks considered. Interestingly, the best policy mix in terms of volatility minimization is not always the one that attains the largest welfare gains. However, looking at the change in overall volatility brought by the optimal scenario, stabilization is always greater when macroprudential policy and fiscal policy coordinate than when optimal macroprudential policy is determined alone. In terms of welfare enhancing, I find that the appropriateness of implementing macroprudential policy is beyond argument under financial shocks (credit risk

shock and spread shock) but not under supply and demand shocks. Finally, the analysis proves that, after financial shocks, federal macroprudential policy delivers lower welfare gains with respect to the national macroprudential scenario. However, in the event of supply or demand shocks, the centrally implemented macroprudential policy entails lower welfare costs with respect to the national macroprudential scenario.

Chapter 3 is organized as follows. In Section 3.2, I review the existing literature related to this study. Section 3.3 describes the two-country model used for the analysis of the baseline and optimal policy scenarios. Section 3.4 contains the equilibrium and market clearing conditions of the model. The calibration is included in Section 3.5. In Section 3.6, I explain how the optimal policy analysis is performed and the welfare measure. Section 3.7, contains the main results of the optimal policy analysis. In Section 3.8, I present the conclusions of this research.

3.2 Related literature

This work contributes to the existing literature that analyzes the optimal policy mix in a monetary union and to the DSGE literature that studies the welfare implications of a variety of policy mix scenarios.

One novelty of this chapter is the analysis of the optimal fiscal and macroprudential policy interaction in a monetary union, taking monetary policy as given. To evaluate the optimal policy, according to one of the approaches explained in Benigno and Woodford (2012), I solve the model using a second order approximation of the equilibrium equations and then evaluate welfare. I measure welfare, in line with Schmitt-Grohé and Uribe (2004), as the conditional expectation of lifetime utility. Like them, I then compare this measure for different optimal fiscal-macroprudential regimes by calculating the welfare costs of each regime. Welfare costs are computed as the fraction of consumption that a household would be willing to give up to be as well off under those optimal regimes as under a benchmark regime. The benchmark regime is a non optimized scenario, that takes fiscal policy as given and

does not include macroprudential policy. Quint and Rabanal (2014) or Rubio and Carrasco-Gallego (2016) are other examples of this method for welfare analysis.

Based on Leeper (1991) definitions, my model combines passive fiscal policies with an active monetary policy, the latter set at the union level. There is an extensive number of papers, which consider different models and shocks and find that the optimal monetary policy needs to maintain price stability. For example, Galí and Monacelli (2005), use a model of a continuum of small open economies for monetary union. They argue that under productivity shocks, the union's central bank should stabilize the price level of the union as a whole. At the same time, the authors state that the lack of a national monetary policy requires that national fiscal policy assumes the stabilization role so as to maximize the union's welfare. Another example is Ferrero (2005), who uses a two-country model for a currency area and concludes that, in the event of government spending shocks, fiscal policy flexibility in debt stabilization implies more welfare gains than monetary policy flexibility in inflation targeting. For this reason, I include a Taylor rule that reacts to changes in inflation and then evaluate, given that common monetary strategy, the optimal alternative policies that compose the policy mix. I share with both papers the relevant role of fiscal policy in a monetary union to compensate the lack of autonomy in monetary policy. However, the main novelty of my model is that national fiscal policies are complemented with optimal macroprudential measures to ensure greater stabilization, especially after certain shocks.

Leith and Wren-Lewis (2006) also apply Leeper's definitions of active and passive policies to a two-country model for a monetary union. According to them, to attain a determinate equilibrium when monetary policy is active, i.e inflation targeting, each economy of the union needs to stabilize its public debt through passive fiscal policy. This provides a rationale for the Stability and Growth Pact of the EMU, while the European Central Bank seeks for inflation stabilization throughout the union. Thus, assuming that monetary policy is active, in my analysis national fiscal policies must be passive, however, unlike Leith and Wren-Lewis (2006), I introduce macroprudential policy as the third instrument of the policy mix.

Galí and Monacelli (2005) and Ferrero (2005) are examples of the analysis of the optimal monetary and fiscal policy mix in a monetary union. But there is also an extensive literature on the optimal macroprudential-monetary policy coordination. Angelini, Neri and Panetta (2012) propose a monetary policy that cooperates with macroprudential policy sharing broader objectives other than just price stability. The authors optimize the value of the monetary and macroprudential parameters when they minimize the volatility of output, inflation and debt. Their results show that macroprudential policy brings very modest benefits in terms of macroeconomic stability after supply shocks, while it becomes key when business cycles are driven by financial shocks. Kannan, Rabanal and Scott (2012) stress that when macroprudential policies complement monetary policy reacting to financial shocks, a less aggressive response of the latter is required. The authors also explain that under technology shocks there is no role for macroprudential policy. In line with them, I conclude that the source of the economic fluctuation is crucial for policymakers to understand the effects of macroprudential policy, as these measures bring more stability and welfare benefits in the event of financial shocks than after supply or demand shocks.

Rubio and Carrasco-Gallego (2016) build a two-country model and also take monetary policy as given to focus on the optimal analysis of macroprudential policy. They compare the welfare gains in two different scenarios: when all the Euro Area countries coordinate in the implementation of national macroprudential policies and when there is no coordination in the implementation of macroprudential policy. They find that, although macroprudential policy coordination achieves more welfare gains, all countries benefit from the non-coordination scenario with respect to the no-macroprudential world. Lambertini, Mendicino and Punzi (2013) also provide evidence on the need to stabilize the financial system and state that the stabilization benefits are larger when macroprudential policies are introduced than when the financial sector is stabilized through monetary measures. I share with them the need of an additional tool, macroprudential instruments, to complement monetary policy. Nevertheless, unlike all these papers, I introduce optimal fiscal measures to the policy mix, in particular, a government spending rule, to complement optimal

macroprudential policy in the pursue of stabilization of the economy and welfare enhancing.

To finish with the review of the monetary-macroprudential interaction literature relevant for this analysis, Quint and Rabanal (2014), in a two-country model with financial frictions for a monetary union, observe that an anti-inflationary monetary policy cannot contain the accelerator effects of the economy. They introduce two alternative ways of reacting to credit conditions: either through a Taylor rule that stabilizes financial variables or through macroprudential policy. They find that macroprudential policy delivers economic stability and reduces the accelerator effects, requiring a smaller response of interest rates. Therefore, they study the use of macroprudential policy and its effects on welfare and macroeconomic volatility. However, they do not consider the effects of a fiscal rule. As opposed to theirs, my analysis considers a monetary policy that only reacts to changes in inflation and the macroprudential-fiscal optimal policy mix is the one that stabilizes output and private and public financial variables. Fiscal policy plays an important role in my model as proportional taxes and the private-public debt channel contribute to the propagation of shocks originated in the financial sector.

Dehmej and Gambacorta (2017) compare national macroprudential policies versus a federal macroprudential policy in a monetary union, as I do in this analysis. They state that asymmetric shocks are ignored by federal macroprudential policy so national macroprudential measures might bring more financial stability. In line with them, my results show that federal macroprudential policy usually brings lower welfare gains than national macroprudential policy, in the event of a financial shock. But as opposed to them, I find that in the event of supply or demand shocks, where the optimal macroprudential policy does not always improve welfare, a federal macroprudential policy implies lower welfare costs than a national one. Rubio (2014) also compares a scenario in which macroprudential policy is centralized against a scenario in which it is decentralized, in the context of a heterogeneous monetary union. The author concludes that the best option depends on the type of heterogeneity of the currency union. Unlike these papers, I allow the federal macro-

prudential policy to target with different intensities the financial indicators of each country. Although the results do not change significantly, I find this design of the federal macroprudential policy more appropriate for the optimal analysis framework as it takes spillovers between countries into account.

As in Chapter 1 and Chapter 2, this chapter considers the private-public debt channel, which is a consequence of the connection between the financial and the public sector and propagates the destabilizing effects of shocks from the financial sector to the broader economy. The channel amplifies the business cycle: when a credit risk shock shrinks private debt, GDP goes down and so do public revenues. This raises public debt, implying a reduction in government spending, as the model includes a government spending rule, and an even deeper fall of GDP. The existence of this channel creates the need for the fiscal-macroprudential policy mix to stabilize public and private debt jointly, and therefore the whole economy. Chapter 2 explains that fiscal policy by itself is unable to cancel the channel because it cannot stabilize both debts at the same time. Based on this I find relevant the use of optimal macroprudential policy in the model to complement national fiscal policies.

My basic modelling framework is an open economy version of the Fernández-Villaverde (2010) new Keynesian model, also used in Chapter 2, with financial frictions as in Bernanke, Gertler and Gilchrist (1999), proportional taxes and a government spending rule. My model differs from the one in Fernández-Villaverde (2010) in the open economy dimension and the inclusion of macroprudential instruments in the policy mix. In particular, this chapter lays out a two-country model for a monetary union with an international goods market and incomplete international financial markets, in line with Quint and Rabanal (2014). Their financial accelerator mechanism differs from mine (the one proposed by Bernanke, Gertler and Gilchrist, 1999) in that they abstract from asymmetric information, so their model does not consider the case in which borrowers default, unless they find themselves completely underwater. Asymmetric information in my model makes financial intermediaries pay an auditing cost to verify that borrowers do not lie about their realized return. This cost results in a direct loss of aggregate national output. Moreover, the predetermined rate on

loans included in Quint and Rabanal (2014) allows domestic financial intermediaries to obtain profits or losses, but I simplify this assumption with a rate on loans that depends on the state of the economy so that domestic financial intermediaries deliver zero profits. This allows to characterize these agents as mere intermediaries between households (who lend funds) and entrepreneurs (borrowers).

The macroprudential instrument of my model is also in line with the one of Quint and Rabanal (2014) because it controls the amount of loans in the economy. Based on Basel III that states that "national authorities should monitor credit growth" and refers to it as an indicator that signals a build-up of system-wide risk, I take the nominal credit growth as the financial indicator to which macroprudential instruments react. Thus, monitoring credit growth is how macroprudential policy in my model pursues its objective of macroeconomic and financial stabilization.

There is a significantly scarce literature on the interaction between macroprudential and fiscal policies, to which this work contributes. Claessens (2014) comments on the need for macroprudential and fiscal authorities to coordinate because he states that some tax policies can contribute to systemic risk by encouraging private leverage (for instance, interest payments that are tax deductable). Estrada and Saurina (2016) argue that fiscal policy can contribute to financial stability by strengthening the incentives to capital financing and can also help to stabilize the business cycle when used countercyclically. However, they find that fiscal policy cannot face the fluctuations of the business cycle by itself. I also analyze the interaction between optimal fiscal and optimal macroprudential policies, that need to cooperate in the pursue of stabilization and welfare enhancing, given that monetary policy cannot be used by national authorities.

3.3 The model

I consider a two-country economy for a monetary union with financial frictions, as in Bernanke, Gertler and Gilchrist (1999), an international financial market and a market for consumption goods that are internationally traded, that follows closely

the closed economy model of Fernández-Villaverde (2010), also used in Chapter 2. Capital and labor are non-mobile across the two countries. The home country is of size n and the foreign country of size $1-n$. Each economy is composed of households, intermediate good producers, final good producers, entrepreneurs, capital goods producers and domestic financial intermediaries. There is a single monetary authority for the currency union, while fiscal authorities are national and macroprudential authorities are either national or supranational depending on the scenario being analyzed. To model the international financial market I follow Quint and Rabanal (2014) and I include international financial intermediaries that connect the domestic financial intermediaries of both countries. The model is explained in detail in Chapters 1 and 2. In what follows, variables and parameters for the foreign country are denoted with superscript $*$.

3.3.1 Households

There is a continuum of households with infinite life. Households consume, work and save. The representative household maximizes his utility function, choosing total consumption, c_t, of foreign or domestic goods, time devoted to work, l_t, and financial assets that can either be deposits, a_t, or government bonds, d_t, both in positive amounts.

The individual's utility function is given by

$$E_t \sum_{t=0}^{\infty} \beta^t e^{\phi_t} \left[\log\left(c_t - h c_{t-1}\right) - \psi \frac{l_t^{1+\vartheta}}{1+\vartheta} \right], \tag{3.1}$$

where $\beta \in (0,1)$ is the discount factor; $h \geq 0$ reflects the degree of habit persistence; $\psi > 0$ denotes the magnitude of the labor disutility relative to consumption utility; and $\vartheta > 0$ is the inverse of the Frisch elasticity of labor supply. Variable ϕ_t represents an intertemporal preference shock with law of motion

$$\phi_t = \rho_d \phi_{t-1} + \sigma_\phi \varepsilon_{\phi,t} \text{ where } 0 < \rho_d < 1 \text{ and } \varepsilon_{\phi,t} \backsim N(0,1). \tag{3.2}$$

Parameter ρ_ϕ is the persistence coefficient and σ_ϕ the volatility of the preference

shock.

The representative household makes decisions subject to the following budget constraint:

$$(1+\tau_c)\,c_t + \frac{a_t}{p_t} + \frac{d_t}{p_t} = (1-\tau_l)\,w_t l_t + \left[1+(1-\tau_R)\,(R_{t-1}-1)\right]\frac{a_{t-1}}{p_t} + R^d_{t-1}\frac{d_{t-1}}{p_t} + T_t + F_t + tre_t, \quad (3.3)$$

where w_t is the real wage; R_{t-1} are interests on last period investment on deposits, and R^d_{t-1} interests on last period investment on public debt. Net transfers that households receive from the government are represented by T_t. The model includes proportional taxes on real consumption, τ_c, on labor income, τ_l and on net returns on deposits, τ_R. Dividends are paid by firms to households, F_t; and tre_t is a net transfer that households receive from entrepreneurs.

Foreign households also maximize lifetime utility subject to their corresponding budget constraint.

As this model has an international goods market, consumption by domestic households is composed by domestic goods and foreign goods in the form of imports. The domestic consumption index follows the form:

$$c_t = \left[(1-\varphi)^{\frac{1}{\zeta}}\,(c_{H,t})^{\frac{\zeta-1}{\zeta}} + \varphi^{\frac{1}{\zeta}}\,(c_{F,t})^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}}, \quad (3.4)$$

where $c_{H,t}$ is the consumption of domestic goods and $c_{F,t}$ is the amount of imports. The parameter $\varphi \in [0,1]$ is a measure of the degree of openness and therefore $1-\varphi$ represents the home bias in consumption. The degree of substitutability between domestic and foreign goods is given by $\zeta > 0$. Total consumption expenditures are given by

$$p_t c_t = p_{H,t} c_{H,t} + p_{F,t} c_{F,t}, \quad (3.5)$$

where the home consumer price index, p_t is composed by the price of domestic goods,

$p_{H,t}$, and the price of foreign goods, $p_{F,t}$.[2]

Households choose their allocations between home and foreign goods maximizing the the consumption index subject to total expenditures.

To express the degree of competitiveness of one country with respect to the other, the variable terms of trade, t_t, relates the price of the domestically produced goods to the price of the goods produced in the foreign country. An increase in t_t implies that home country goods are more competitive than foreign country goods and a reduction of t_t means that the foreign country increases its competitiveness with respect to the home country.

$$t_t = \frac{p_{F,t}}{p_{H,t}}. \tag{3.6}$$

3.3.2 Intermediate goods producers

These agents produce differentiated goods that are then sold in a monopolistic market to final good producers, who use them in their production process. Each intermediate good producer, i, hires labor from households, l_{it}, and rent capital from entrepreneurs, k_{it-1}, paying in return real wages and a real interest rate on capital, respectively. Labor and capital are the production factors used to create their output y_{it} through a Cobb-Douglas production function

$$y_{it} = e^{z_t} k_{it-1}^{\alpha} l_{it}^{1-\alpha}, \tag{3.7}$$

where $0 \leq \alpha \leq 1$ is the capital share of the intermediate production function.

Technology follows an exogenous AR(1) process $z_t = \rho_z z_{t-1} + \sigma_z \varepsilon_{z,t}$ where $0 < \rho_z < 1$ and $\varepsilon_{z,t} \backsim N(0,1)$, being ρ_z the persistence coefficient and σ_z the volatility of the technology shock.

Labor and capital are rented to households in exchange for real wages w_t and to en-

[2]For simplicity, I assume that the law of one price holds so the prices of the goods produced at the foreign country are the same across countries and so are the prices of the goods produced at the home country. That is, $p_{H,t} = p^*_{H,t}$ and $p_{F,t} = p^*_{F,t}$. As this model represents a monetary union all prices are expressed in the same monetary units.

trepreneurs (whose problem is explained below) in exchange for a rental real interest rate r_t, respectively. Cost minimization implies

$$k_{it-1} = \frac{\alpha}{1-\alpha}\frac{w_t}{r_t}l_{it}\frac{p_t}{p_{H,t}}. \tag{3.8}$$

These firms reset their prices through a Calvo pricing mechanism by which, each period, a fraction $1-\theta$ of them can choose a new price, while a fraction θ of firms have to keep the previous period price which is then indexed to past inflation.

Firms resetting their price in period t maximize the following expression:[3]

$$E_t \sum_{\tau=0}^{\infty} (\beta\theta)^{\tau} \frac{\lambda_{t+\tau}}{\lambda_t} \left[\left(\prod_{s=1}^{\tau} \frac{\Pi_{H,t+s-1}^{\chi}}{\Pi_{H,t+s}} \frac{p_{H,it}}{p_{H,t}} - mc_{t+\tau} \right) y_{it+\tau} \right], \tag{3.9}$$

subject to a sequence of demand functions given by the final good producer

$$y_{it+\tau} = \left(\prod_{s=1}^{\tau} \frac{\Pi_{H,t+s-1}^{\chi}}{\Pi_{H,t+s}} \frac{p_{H,it}}{p_{H,t}} \right)^{-\varepsilon} y_{t+\tau}, \tag{3.10}$$

for $\tau = 0, 1, 2, ...$ where the marginal value of wealth of households, $\frac{\lambda_{t+\tau}}{\lambda_t}$ is exogenous for the monopolistic firm; mc_t denotes the marginal cost of the intermediate good producer; $p_{H,it}$ is the price set in period t by the domestic intermediate firm i; $p_{H,t}$ is the aggregate domestic price level; $\Pi_{H,t}$ denotes domestic inflation and therefore $\frac{\Pi_{H,t+s-1}^{\chi}}{\Pi_{H,t+s}}$ represents the degree of indexation of prices to past inflation; $y_{it+\tau}$ denotes output in period $t+\tau$ for a firm that last reset its price in period t; $y_{t+\tau}$ is the aggregate level of output in time $t+\tau$ and $\varepsilon \geq 1$ is the elasticity of substitution across goods. Let the domestic reset price relative to the domestic price level be $\bar{\Pi}_{H,t} = \frac{\bar{p}_{H,t}}{p_{H,t}}$.

[3]The expression represents the discounted sum of the difference between the optimizing firm's revenues and its marginal cost, that is, the discounted profits.

So the first order conditions for these intermediate firms are:[4]

$$\frac{k_{t-1}}{l_t} = \frac{\alpha}{1-\alpha}\frac{w_t}{r_t}\frac{p_t}{p_{H,t}}, \tag{3.11}$$

$$mc_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\frac{w_t^{1-\alpha}r_t^{\alpha}}{e^{z_t}}\left(\frac{p_t}{p_{H,t}}\right)^{1-\alpha}, \tag{3.12}$$

$$\varepsilon f_t^1 = (\varepsilon - 1) f_t^2, \tag{3.13}$$

where

$$f_t^1 = \lambda_t mc_t y_t + \beta\theta E_t\left(\frac{\Pi_{H,t}^{\chi}}{\Pi_{H,t+1}}\right)^{-\varepsilon} f_{t+1}^1, \tag{3.14}$$

and

$$f_t^2 = \lambda_t \bar{\Pi}_{H,t} y_t + \beta\theta E_t\left(\frac{\Pi_{H,t}^{\chi}}{\Pi_{H,t+1}}\right)^{1-\varepsilon} f_{t+1}^2\left(\frac{\bar{\Pi}_{H,t}}{\bar{\Pi}_{H,t+1}}\right). \tag{3.15}$$

where, following Fernández Villaverde (2010), f_t^1 and f_t^2 are two auxiliary variables.

Taking into account the Calvo's pricing mechanism, the price index evolution is given by

$$1 = \theta\left(\frac{\Pi_{H,t-1}^{\chi}}{\Pi_{H,t}}\right)^{1-\varepsilon} + (1-\theta)\,\bar{\Pi}_{H,t}^{(1-\varepsilon)}. \tag{3.16}$$

3.3.3 Final goods producers

Final goods producers buy intermediate goods from intermediate goods producers and combine them to obtain the homogeneous final good according to the following Dixit-Stiglitz technology function:

$$y_t = \left(\int_0^1 y_{it}^{\frac{\varepsilon-1}{\varepsilon}} di\right)^{\frac{\varepsilon}{\varepsilon-1}}, \tag{3.17}$$

[4]Since all intermediate good producers face the same prices and because of market clearing, subscript i can be removed from the previous expression, meaning all the monopolistic producers choose the same ratio for the production factors they use $\frac{k_{it-1}}{l_{it}}$ and so, henceforth, capital and labor will be expressed in aggregate levels.

where y_t is the aggregate demand of the economy, and $\varepsilon > 1$ is the elasticity of substitution across goods. The final good is sold to consumers, in the form of private consumption, or to the government, in the form of public consumption, in a perfectly competitive market. These firms maximize profits taking both the price of the intermediate good $p_{H,it}$ and the price of the final good $p_{H,t}$ as given. The domestic price level is given by

$$p_{H,t} = \left(\int_0^1 p_{H,it}^{1-\varepsilon} di \right)^{\frac{1}{1-\varepsilon}}. \tag{3.18}$$

3.3.4 Capital goods producers

Capital goods producers operate in a perfectly competitive market and create new capital, x_{t+1} via the following production function:

$$x_{t+1} = x_t + \left(1 - S\left[\frac{i_t}{i_{t-1}} \right] \right) i_t, \tag{3.19}$$

where $S\left[\frac{i_t}{i_{t-1}}\right]$ denotes adjustment costs, such that $S'[\cdot] > 0; S''[\cdot] > 0; S[1] = 0;$ and $S'[1] = 0$. To this end, they use investment, i_t, and installed capital, x_t, which is previously purchased from entrepreneurs.

These agents maximize their discounted profits subject to $x_t = (1-\delta) k_{t-1}$, where $\delta \in [0,1]$ is the capital depreciation rate. The law of motion of capital is given by the following expression:

$$k_t = (1-\delta) k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}} \right] \right) i_t. \tag{3.20}$$

3.3.5 Entrepreneurs

Entrepreneurs are in charge of transforming installed capital into inputs for use by intermediate good producers. Entrepreneurs buy new capital, k_t, from capital goods producers at a price q_t, to undertake their investment. Their output is then rented to intermediate goods producers at a cost r_{t+1} per unit of capital rented, k_t.

Then the capital goods producers repurchase the old non-depreciated capital paying $q_{t+1}(1-\delta)$ to the entrepreneurs at the end of the period. Variable $\Pi_{H,t}$ denotes domestic inflation. Therefore, the ex-post average return of the entrepreneur per unit of investment between t and $t+1$, R^k_{t+1}, can be defined as

$$R^k_{t+1} = \Pi_{H,t+1}\frac{r_{t+1} + q_{t+1}(1-\delta)}{q_t}. \tag{3.21}$$

Their technology is affected by an idiosyncratic shock, ω_{t+1}, that is lognormally distributed with a cumulative distribution function represented by $F(\omega, \sigma_{\omega,t})$ with parameters $\mu_{\omega,t}$ and $\sigma_{\omega,t}$ such that $E_t\omega_{t+1} = 1$ for all t.

The standard deviation of the idiosyncratic shock represents the credit risk of the model. The dispersion follows:

$$\frac{\sigma_{\omega,t}}{\sigma_\omega} = \left(\frac{\sigma_{\omega,t-1}}{\sigma_\omega}\right)^{\rho_{\sigma_\omega}} \exp\left(\eta_{\sigma_\omega}\varepsilon_{\sigma_\omega,t}\right) \text{ where } \varepsilon_{\sigma_\omega,t} \backsim N(0,1). \tag{3.22}$$

Parameter $\rho_{\sigma_\omega} \in [0,1]$ is the persistence coefficient and η_{σ_ω} is the volatility of the shock that is revealed at the end of the period, just before the investment decisions for $t+1$ are taken.

As in Bernanke, Gertler and Gilchrist (1999), entrepreneurs decide on the amount of new installed capital they want to purchase and therefore on the external funds they need, given their networth. External funds consist of loans (or liabilities of the entrepreneurs) borrowed from financial intermediaries, b_t.

At the moment of the debt contract agreement there is aggregate uncertainty because R^k_{t+1} is not known yet. The contract will establish a state-contingent non-default repayment R^l_{t+1} (dependent on the ex-post realization of R^k_{t+1}) that the entrepreneur promises to pay to the financial intermediary in case he succeeds in his investment project. However, although entrepreneurs observe their outcome for free, financial intermediaries need to pay a cost in order to verify that entrepreneurs tell the truth about their return. This is because the realization of ω_{t+1} is private information to entrepreneurs, and the contract is signed before it is known, what leads to a

moral hazard problem. This is called a costly state verification, that I modeled as in Bernanke, Gertler and Gilchrist (1999), and that is solved via a standard debt contract.

The standard debt contract is solved by maximizing the entrepreneur's expected returns subject to the participation constraint of the financial intermediary.

3.3.6 Domestic Financial Intermediaries

Domestic financial intermediaries operate in a perfectly competitive market, receiving deposits from households, a_t, and lending loans to entrepreneurs, b_t. They also make use of the international financial market. In case the demand for loans exceeds the amount of domestic deposits, domestic financial intermediaries obtain funds from the international financial market in the form of uncontingent bonds, $B_t > 0$, that are lent to entrepreneurs in the form of loans. When there is a surplus of domestic deposits relative to the demand for loans, domestic financial intermediaries deposit the excess of funds in the international financial markets, $B_t < 0$.

Domestic financial intermediaries pay an interest rate, R_t, to households for the deposits. At the same time, they receive an interest rate, R_t^l, from entrepreneurs for the loans they lend. In case they borrow funds from the international financial market they also pay an interest rate, R_t, to international financial intermediaries. In case they lend the surplus of funds in the international financial market they receive an interest rate, R_t, from the international financial intermediaries. In this model, $nB_t = -(1-n)B_t^*$ and, assuming that both countries are of equal size, $B_t = -B_t^*$.

Their objective function is given by

$$\left\{ \left[1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] R_{t+1}^l b_t + \left(1-\mu\right) \int_0^{\varpi_{t+1}} \omega dF\left(\omega, \sigma_{\omega,t}\right) R_{t+1}^k p_{H,t} q_t k_t - s_t R_t \left(a_t + B_t\right) \right\}, \tag{3.23}$$

which shows expected returns in case of a successful project, plus revenues in case of default, minus the costs in terms of deposits for the financial intermediary. The variable s_t is a spread that domestic financial intermediaries also pay under the

concept of intermediation costs and that is paid back to households in a lump-sum way. Also, following Fernández-Villaverde (2010)

$$s_t = 1 + e^{\overline{s}+\widetilde{s}_t}, \tag{3.24}$$

and

$$\widetilde{s}_t = \rho_s \widetilde{s}_{t-1} + \sigma_s \varepsilon_{s,t} \text{ where } 0 < \rho_s < 1 \text{ and } \varepsilon_{s,t} \backsim N(0,1). \tag{3.25}$$

Parameter ρ_s is the persistence coefficient and σ_s is the volatility of the shock.

3.3.7 International Financial Intermediary

Following Quint and Rabanal (2014), the model incorporates an intermediary between domestic financial intermediaries of the home country and domestic financial intermediaries of the foreign country: international financial intermediaries. These agents borrow from the country with excess loanable funds to lend them to the country that has a shortage of loanable funds. They pay to the lending country a rate equal to the interest on deposits of that country and receive from the borrowing country a rate equal to the interest on deposits of that other country. Incomplete markets in this model imply that the interest rate differs across countries. Thus, the differential between the deposit interest rates of both countries equals the profits made by international financial intermediaries[5]. This differential, also known as country debt premium, is given by

$$R_t - R_t^* = \kappa_t e^{\Omega\left(\frac{B_t}{p_t y} - \frac{B}{py}\right)} - 1. \tag{3.26}$$

For simplicity, as in Quint and Rabanal (2014), I take the home country as the reference so that the debt premium depends on the ratio of real international debt, $\frac{B_t}{p_t}$, to steady state real GDP, y, of the home country. In what follows I will denote real international debt by $\bar{B}_t$ and real private debt by $\bar{b}_t$. If the home country

[5]Schmitt-Grohé and Uribe (2002) propose different alternatives to induce stationarity in a small open economy model with incomplete asset markets. In this line, I introduce an interest rate that is increasing in the level of debt.

borrows from the international market, $B_t > 0$ and $R_t > R_t^*$. The parameter $\Omega > 0$ denotes the elasticity of the debt premium; and κ_t is a debt premium shock that follows an exogenous AR(1) process $\kappa_t = \rho_\kappa \kappa_{t-1} + \sigma_\kappa \varepsilon_{\kappa,t}$ where $0 < \rho_\kappa < 1$ and $\varepsilon_{\kappa,t} \backsim N(0,1)$, being ρ_κ the persistence coefficient and σ_κ the volatility of the debt premium shock.

Profits obtained by international financial intermediaries are distributed porportionally across households of both countries.

3.3.8 Fiscal Authority

There is a national fiscal authority (or government) that finances its expenditures via taxes and public debt, according to the following budget constraint:

$$\frac{d_t}{p_t} = g_t + R_{t-1}^d \frac{d_{t-1}}{p_t} - tax_t, \tag{3.27}$$

where d_t denotes current issue of public debt; g_t is government spending; and tax_t denotes tax revenues defined by

$$tax_t = \tau_c c_t + \tau_l w_t l_t + \tau_R \left(R_{t-1} - 1\right) \frac{a_{t-1}}{p_t}. \tag{3.28}$$

As in Fernández Villaverde (2010), I assume that government spending evolves by the following fiscal rule:

$$\frac{g_t}{g} = \left(\frac{g_t}{g}\right)^{\gamma_g} \exp\left(d_g \frac{d_{t-1}}{\Pi_t y_t} - \frac{d}{\Pi y}\right) \exp\left(\sigma_g \varepsilon_{g,t}\right), \text{ where } \varepsilon_{g,t} \backsim N(0,1). \tag{3.29}$$

Parameter $d_g \leq 0$ is the sensitivity of government expenditure to changes in the ratio of debt over output, its sign reflects the objective of public debt stabilization; $\gamma_g \in [0,1]$ is the persistence coefficient; and σ_g is the volatility of the government spending shock.

3.3.9 Monetary Authority

The monetary authority or central bank is common for both countries and uses monetary policy to stabilize the monetary union gross inflation rate, Π_t^{MU}, and real output, y_t^{MU}. With that aim, the central bank sets the monetary policy instrument, or interest rate for the union. This analysis takes into account the active/passive definitions introduced by Leeper (1991). Leeper explains that an active policy is the one unconstrained by sovereign debt and a passive policy is the one constrained by current budgetary conditions and active authority actions. I consider the scenario where different national passive fiscal policies are combined with a single active monetary policy that stabilizes inflation at the union level.

The central bank follows a standard Taylor Rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\gamma_R} \left(\left(\frac{\Pi_t^{MU}}{\Pi^{MU}}\right)^{\gamma_\Pi} \left(\frac{y_t^{MU}}{y^{MU}}\right)^{\gamma_y}\right)^{(1-\gamma_R)} \exp(\sigma_m \varepsilon_{m,t}), \tag{3.30}$$

where $\gamma_R \in [0,1]$ is the persistence parameter; $\gamma_\Pi \geq 0$ and $\gamma_y \geq 0$ indicate how strong is the response of the interest policy rate to deviations of Π_t^{MU} and y_t^{MU} from their steady states, respectively; and σ_m is the volatility of the monetary policy shock, $\varepsilon_{m,t} \backsim N(0,1)$.

The nominal interest rate is modified through open market operations financed by transfers, T_t and T_t^* for the home and foreign country, respectively.

3.3.10 Macroprudential policy

In this section, I include a macroprudential authority that sets policies to stabilize the financial system. Through macroprudential policy instruments the amount of loans to be lent to the private financial sector is controlled and private debt volatility is reduced in order to guarantee a more stable cycle.

Therefore, following Quint and Rabanal (2014), I introduce a macroprudential tool that controls the ability to lend of the domestic financial intermediaries in the fol-

lowing way:

$$\frac{1}{\eta_t}\left(B_t + a_t\right) = b_t, \tag{3.31}$$

where η_t is a new variable that affects the credit market conditions.

The macroprudential regulation will affect financial variables countercyclically. Higher values of η_t reflect a tightening macroprudential policy, while lower values reflect an easing macroprudential policy. This macroprudential rule implies that, when the regulation is tightening, domestic financial intermediaries can only lend a fraction of the funds they get from households and from international financial intermediaries. However, in line with Quint and Rabanal (2014), I allow the macroprudential instrument to behave symmetrically and go below one. Thus, when the regulation is easing, the central bank will provide liquidity to domestic financial intermediaries so that they can lend more than the amount of deposits and international funds they hold on their balance sheet.

In line with Quint and Rabanal (2014), I also make η_t dependent on the deviation of credit market conditions, Ψ_t, from their steady state, Ψ, as follows:

$$\eta_t = \left(\frac{\Psi_t}{\Psi}\right)^{\gamma_\eta}, \tag{3.32}$$

where $\gamma_\eta > 0$ reflects how responsive η_t is to the indicator of credit market conditions considered. Notice that macroprudential policies do not affect the steady state since $\eta = 1$ whenever $\Psi_t = \Psi$.

Chapter 1 includes an analysis of the two alternative macroprudential instruments proposed by Quint and Rabanal (2014). They first define Ψ_t as the deviation of the nominal private credit growth and second as the deviation of the private credit-to-GDP ratio.

The results obtained in Chapter 1, for a closed economy, show that macroprudential policy always stabilizes private debt but GDP only when it targets nominal credit growth. Therefore, as my objective is to analyze macroprudential policy as a way of attaining macroeconomic and financial stability, in this chapter I define Ψ_t as the

nominal private credit growth. This is consistent with Basel III that states that monitoring excessive credit growth is one of the most important financial indicators that should be consider when implementing macroprudential policy. Therefore,

$$\Psi_t = \frac{\bar{b}_t}{\bar{b}_{t-1}}\Pi_t. \tag{3.33}$$

Thus, the macroprudential instrument becomes tightening when there is an increase in the nominal private credit growth and easing if the latter decreases.

As in Rubio (2014), Dehmej and Gambacorta (2017) and Chapter 2 of this dissertation, I analyze the case of federal macroprudential policy. In line with these authors, I consider that, when federally-implemented, the macroprudential tool is the same in both countries of the union. However, as opposed to the mentioned papers, the federal macroprudential rule in this model does not target the financial indicator of each country with the same degree of responsiveness, i.e. I allow γ_η and γ_η^* to be different, therefore:

$$\eta_t^{MU} = n\left(\frac{\Psi_t}{\Psi}\right)^{\gamma_\eta} + (1-n)\left(\frac{\Psi_t^*}{\Psi^*}\right)^{\gamma_\eta^*}. \tag{3.34}$$

3.4 Aggregation and Equilibrium

Aggregate output in the model is given by

$$y_t = c_{H,t} + \frac{1-n}{n}c_{H,t}^* + i_t + g_t + \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\left(r_t + q_t\left(1-\delta\right)\right)k_{t-1}, \tag{3.35}$$

from the demand side. And the aggregate supply is

$$y_t = \frac{1}{\upsilon_t}e^{z_t}k_{t-1}^{\alpha}l_t^{1-\alpha}, \tag{3.36}$$

being υ_t the inefficiency created by price dispersion that evolves as:

$$\upsilon_t = \theta\left(\frac{\Pi_{H,t-1}^{\chi}}{\Pi_{H,t}}\right)^{-\varepsilon}\upsilon_{t-1} + (1-\theta)\left(\bar{\Pi}_{H,t}\right)^{-\varepsilon}. \tag{3.37}$$

The net foreign asset position is

$$n\bar{B}_t = nR_{t-1}\frac{\bar{B}_{t-1}}{\Pi_t} + n\frac{p_{F,t}}{p_t}c_{F,t} - (1-n)\frac{p_{H,t}}{p_t}c^*_{H,t}. \tag{3.38}$$

The equilibrium in this model, considering that there is a home country and a foreign country, can be defined as the sequence of quantities $\{c_t,\ c_{H,t},\ c_{F,t},\ l_t,\ a_t,\ k_t,\ i_t,\ b_t,\ B_t,\ c^*_t,\ c^*_{H,t},\ c^*_{F,t},\ l^*_t,\ a^*_t,\ k^*_t,\ i^*_t,\ b^*_t,\ B^*_t\}_{t=0}^{\infty}$; fiscal policy $\{g_t,\ tax_t,\ d_t,\ g^*_t,\ tax^*_t,\ d^*_t\}_{t=0}^{\infty}$; prices $\{p_t,\ p_{H,t},\ p_{F,t},\ r_t,\ w_t,\ q_t,\ p^*_t,\ r^*_t,\ w^*_t,\ q^*_t\}_{t=0}^{\infty}$, and interest rates $\{R^d_t,\ R_t,\ R^k_t,\ R^l_t,\ R^{d*}_t,\ R^*_t,\ R^{k*}_t,\ R^{l*}_t\}_{t=0}^{\infty}$, given exogenous variables $\{z_t,\ \sigma_{\omega,t},\ \widetilde{s}_t,\ \phi_t,\ z^*_t,\ \sigma^*_{\omega,t},\ \widetilde{s}^*_t,\ \phi^*_t,\ \kappa_t\}_{t=0}^{\infty}$, such that:

- optimization problems are satisfied for all agents of both countries in the model; and
- all markets clear, that is, in the case of the home country

$$y_t = c_{H,t} + \frac{1-n}{n}c^*_{H,t} + i_t + g_t + \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\left(r_t + q_t\left(1-\delta\right)\right)k_{t-1},$$

$$y_t = \frac{1}{\upsilon_t}e^{z_t}k^{\alpha}_{t-1}l^{1-\alpha}_t,$$

$$l^s_t = l^d_t,$$

$$nB_t = (1-n)\,B^*_t$$

$$\begin{cases} a_t + B_t = b_t & \text{if macroprudential policy is not included,} \\ \frac{1}{\eta_t}\left(a_t + B_t\right) = b_t & \text{if macroprudential policy is included.} \end{cases}$$

- plus the laws of motion

$$k_t = (1-\delta)k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right)i_t, \text{and}$$

$$\frac{d_t}{p_t} = g_t + R^d_{t-1}\frac{d_{t-1}}{p_t} - tax_t.$$

$$n\bar{B}_t = nR_{t-1}\frac{\bar{B}_{t-1}}{\Pi_t} + n\frac{p_{F,t}}{p_t}c_{F,t} - (1-n)\frac{p_{H,t}}{p_t}c^*_{H,t}.$$

For the foreign country the market clearing is replicated in the same way but using the foreign variables of the model.

3.5 Calibration of the parameters and steady state

Table 3.1 shows the parametrization I use in the model, which is the same as in Chapter 2. Parameters d_g and d^*_g, from the fiscal policy rules and γ_η and γ^*_η, from the macroprudential rules, depend on the optimized value that minimize a specific loss function, depending on the scenario considered.

Open economy. I assume that both countries are of equal size, $n = 0.5$. Then I set the fraction of imported goods from the foreign country to the home country over GDP to 0.1 and the fraction of imported goods from the home country to the foreign country over foreign GDP to 0.11. Therefore, the home country is a net exporter and the foreign country a net importer in steady state what, taking into account the net foreign asset position, implies that international debt is different from 0. In line with Faia (2001), the substitutability between domestic and foreign goods is set to $\zeta = 1.5$ and the terms of trade, t, are 1 in steady state, what means that the price of the home country produce goods is the same to the price of the foreign country produced goods. The debt elasticity of the country premium is different to zero to induce stationarity (Schmitt-Grohe and Uribe, 2002), concretely I use value estimated in Quint and Rabanal (2014), $\Omega = 0.0043$.

Preferences. I set the discount factor to $\beta = 0.999$, being the same for both countries and $\Pi_H = \Pi_F = \Pi = \Pi^* = 1.005$ what imply an average annual real interest rate equal to 0.4%. Habits on consumption are $h = 0.5$, and the Frisch elasticity of labor is $1/\vartheta = 2$, consistent with the calibration in Fernández Villaverde (2010). Labor in steady state is $l = \frac{1}{3}$.

Technology. The capital share, α, is set equal to 0.33; capital depreciation rate, δ, equals 8.9% at an annual rate; and capital adjustment costs are such that $S^{"}[1] =$

14.477. The Calvo pricing parameter, as calibrated in Fernández Villaverde (2010), θ, is 0.8 what means on average 5 quarters of duration of prices; the degree of indexation to past inflation, χ, equals 0.6; and the elasticity of substitution across goods, $\varepsilon = 8.577$, what implies a markup of around 13% in the goods sector.

Financial variables. Following the calibration in Fernández Villaverde (2010) the loan-to-capital ratio is set equal to $\frac{\bar{b}}{k} = \frac{1}{3}$ and the survival rate of entrepreneurs to $\gamma^e = 0.975$; then, as in Fernández Villaverde (2012), I consider that monitoring costs, μ, are 15% of the entrepreneur's output and that the average spread on loans, s, is 0.25%. Finally, in line with the calibration in Bernanke et al. (1999), the annual probability of default in my model is 3%.

Fiscal policy. The steady state values for tax rates are taken from Fernández-Villaverde (2010) and equal to $\tau_l = 0.24$, $\tau_r = 0.42$; government spending-to-GDP ratio equals 20%, and the debt-to-GDP ratio is 60%. Given these values τ_c is determined from the government's budget constraint. Finally, the benchmark value of d_g is equal to -0.01, in line with Chapter 2.

Monetary policy. In the analysis below, monetary policy is conducted at the union level. I assume that the response of intervention rate to changes in inflation is $\gamma_{\Pi}(1-\gamma_R) = 1.5$ what implies that the monetary union authorities have the objective of inflation stabilization, so monetary policy is active.

Macroprudential policy. The baseline macroprudential policy scenario is the no macroprudential policy regime that implies that γ_η and γ_η^* equal 0. When macroprudential policy is introduced in the model γ_η and γ_η^* take the optimized values that minimize the corresponding loss function.

Shock processes. I consider quite permanent shock processes, therefore, I set autoregressive coefficients, as in Fernández Villaverde (2012), equal to 0.95, and standard deviations are taken from the empirical evidence and past literature, as summarized in Table 3.1.

3.6 Optimal policy analysis

This section explains the optimal policy methodology used in this chapter, which is performed in two steps. I first optimize the value of the policy parameters that minimize different loss functions depending on the policy mix scenario considered to obtain the optimal policy rules. Secondly, I evaluate the welfare gains or costs for the home country, the foreign country and the monetary union that each computed optimal policy rule implies.

The analysis is carried out for optimal macroprudential policies set both individually and interacting with optimal fiscal policies (that is, both policies sharing the same objectives). Moreover, I compare the results of implementing national macroprudential policies versus implementing federal macroprudential policies. The analysis is replicated for different shocks, all of them originating in the home country, to obtain more robust results.

For the first step of the optimal policy analysis, I consider that the authorities' objective is to minimize the volatility of certain variables of the economy. When macroprudential policy is conducted at the national level, authorities use macroprudential and fiscal policies to minimize the volatility of national variables.[6] When macroprudential policy is federally implemented, the supranational authority aims at minimizing the volatility of union-wide aggregate variables.[7]

The baseline scenario with respect to which all optimal results are calculated consists of no macroprudential policy implementation and a given fiscal policy. In line with Leeper (1991), fiscal policy will be passive stabilizing public debt through a government spending rule that decreases (increases) by 1% for every unit of increase (decrease) in public leverage. Thus, in the baseline scenario, fiscal parameters are $d_g = -0.01$ in the home country and $d_g^* = -0.01$ in the foreign country, which is consistent with the calibration in Chapter 2.

[6] These are the "Home country LF" and the "Foreign country LF" minimization objective scenarios of Tables 3.2, 3.3, 3.4, 3.5 and 3.6.

[7] This is the "Union-wide LF" minimization objective scenario of Tables 3.2, 3.3, 3.4, 3.5 and 3.6.

In Chapter 1, I find there is a trade-off between stabilizing output and financial variables. This leads the optimal analysis of this chapter to assess a loss function including output and financial instruments volatilities, to quantify this trade-off. Therefore, in the loss function, Ψ is the financial indicator targeted by the macroprudential authority, nominal credit growth. When macroprudential policy interacts with fiscal policy to optimize the value of the policy parameters, public debt-to-GDP volatility is also introduced in the loss function. Parameter $\phi_y \in [0,1]$ indicates the relative weight of σ_y in the objective function.[8] In line with Angelini, Neri and Panetta (2012), I set $\phi_y = \phi_{y^*} = \phi_{yMU} = 0.5$. Following these authors, I give a weight equal to one in the loss function to the variance of the financial indicator, σ_Ψ, because they are the "key argument of the loss function that the macroprudential authority seeks to minimize". When macroprudential and fiscal policy interact I set $\phi_y = \phi_{y^*} = \phi_{yMU} = 1$ because, as in Angelini, Neri and Panetta (2012), the common loss function is the result of the aggregation of each authority' s individual loss function.[9] Then I follow the above criterion to give a weight equal to one to the variance of public debt-to-GDP, $\sigma_{\frac{d}{y}}$. To ensure that the optimized values of the macroprudential parameters, γ_η and γ_η^*, are reasonable and consistent with the existing literature, I impose a lower limit of 0 and an upper limit of 5.00 to analysis. Similarly, the optimized values of the fiscal parameters, d_g and d_g^*, are restricted to a range between -0.09 and 0.

The different representations of the loss functions that the respective authorities want to minimize are described below. I calculate the loss under the alternative policy-mix scenarios considered. The results are detailed in Section 3.7.

In a first approach, the optimal macroprudential policy is set by a macroprudential authority concerned with the variability of output and nominal credit growth, given a single active monetary policy and national passive fiscal policies. In a second approach, macroprudential and fiscal authorities coordinate to implement optimal

[8] The loss functions represent a loss in the sense that less volatility is preferred to more.

[9] The assesment of the optimal fiscal policy implemented alone lies beyond the scope of present analysis, therefore the individual fiscal policy loss function is not shown in this chapter. However, the relative weight of 0.5 for GDP volatility in the individual fiscal policy loss function is implied by the setting of $\phi_y = \phi_{y^*} = \phi_{yMU} = 1$ in the common loss function.

macroprudential and fiscal policies at the same time. At the same time, as I mentioned before, these two approaches are undertaken for two different scenarios, one in which macroprudential policy is set at the national level and another in which macroprudential policy is set at the union level. When the home country sets the optimal macroprudential policy, the home country macroprudential authority determines the value of γ_η that minimizes a home country macroprudential loss function

$$\mathcal{L}_{MaP} = \sigma^2_{\Psi} + \phi_y \sigma^2_y, \tag{3.39}$$

and when the home country sets the optimal macroprudential and fiscal policies all together, the home country macroprudential and fiscal authorities determine the values γ_η and d_g that minimize a home country common loss function

$$\mathcal{L} = \sigma^2_{\Psi} + \sigma^2_{\frac{d}{y}} + \phi_y \sigma^2_y. \tag{3.40}$$

Similarly, when the foreign country sets the optimal macroprudential policy, the foreign country macroprudential authority determines the value of γ^*_η, that minimizes a foreign country macroprudential loss function

$$\mathcal{L}^*_{MaP} = \sigma^2_{\Psi^*} + \phi_{y^*} \sigma^2_{y^*}, \tag{3.41}$$

and when the foreign country sets the optimal macroprudential and fiscal policies all together, the foreign country macroprudential and fiscal authorities determine the values of γ^*_η and d^*_g that minimize a foreign country common loss function

$$\mathcal{L}^* = \sigma^2_{\Psi^*} + \sigma^2_{\frac{d^*}{y^*}} + \phi_{y^*} \sigma^2_{y^*}. \tag{3.42}$$

Finally, I consider the cases in which macroprudential policy is implemented at the union level by a supranational authority. Following the first approach, the supranational authority determines the optimal federal macroprudential policy given a single active monetary policy and national passive fiscal policies. In this case the supranational authority determines the value of γ_η and γ^*_η that minimize the union-

wide aggregate macroprudential loss function

$$\mathcal{L}_{MaP}^{MU} = \sigma_{\Psi^{MU}}^2 + \phi_{y^{MU}} \sigma_{y^{MU}}^2, \tag{3.43}$$

Then, following the second approach, the supranational authority determines the optimal federal macroprudential policy and coordinates with the national fiscal authorities, given a single active monetary policy. Thus, the supranational authority establishes the value of γ_η and γ_η^* and, at the same time, the national fiscal authorities optimize the values of d_g and d_g^* that minimize the union-wide aggregate common loss function

$$\mathcal{L}^{\mathcal{MU}} = \sigma_{\Psi^{MU}}^2 + \sigma_{\frac{d^{MU}}{y^{MU}}}^2 + \phi_{y^{MU}} \sigma_{y^{MU}}^2. \tag{3.44}$$

For the second step of the optimal policy analysis I follow Schmitt-Grohé and Uribe (2004) to obtain the welfare results. Thus, I compute welfare as the conditional expectation of lifetime utility as of time zero assuming that at time zero all variables in the economy equal their non-stochastic steady state values. This ensures that the economy starts from the same initial point under all policy regimes (because the non-stochastic steady state is the same across all policy regimes that I consider). This conditional welfare criterion allows not to neglect the welfare effects during the transition from the non-stochastic to the stochastic steady state (different policy regimes are associated with different stochastic steady states).

I define welfare for the home country as:

$$\mathcal{W} = E_t \sum_{t=0}^{\infty} \beta^t e^{\phi_t} \left[\log\left(c_t - h c_{t-1}\right) - \psi \frac{l_t^{1+\vartheta}}{1+\vartheta} \right], \tag{3.45}$$

and for the foreign country as

$$\mathcal{W}^* = E_t \sum_{t=0}^{\infty} \beta^t e^{\phi_t^*} \left[\log\left(c_t^* - h c_{t-1}^*\right) - \psi \frac{l_t^{*1+\vartheta}}{1+\vartheta} \right]. \tag{3.46}$$

The aggregate welfare for the union as a whole is computed as the weighted sum of

the welfare in the two countries:

$$\mathcal{W}^{MU} = n\mathcal{W} + (1-n)\,\mathcal{W}^{*}. \tag{3.47}$$

In order to compare welfare in the different optimal policy mix scenarios considered, I adopt a measure of the welfare costs also in line with Schmitt-Grohé and Uribe (2004). This measure indicates the fraction of consumption that a household would be willing to give up to be indifferent between the benchmark scenario (no macroprudential policy and a given fiscal policy) and each computed optimal rule.

3.7 Results of the optimal policy analysis

The first step of the optimal policy analysis above-described gives information about the optimized values of the policy parameters that minimize a variety of loss functions. Tables 3.2, 3.3, 3.4 and 3.5 and 3.6 contain the results of the part of the analysis described in this Section.

To be more precise, in all these tables, the first row of each shock ("Home country LF") represents the scenarios in which the home national policy minimizes a home country loss function. The second row of each shock ("Foreign country LF") displays the scenarios in which the foreign national policy minimizes a foreign country loss function. The third row of each shock ("Union-wide LF") reports the scenarios in which federal macroprudential policy (and national fiscal policies in Tables 3.4, 3.5) minimizes a union-wide loss function. The results suggest that when deciding on the optimal macroprudential rules, policymakers should consider both the shock that hits the economy and the coordination between fiscal and monetary authorities.

The optimized values of the policy parameters are contained in Tables 3.2 and 3.4, for each home country shock considered. Cells containing a horizontal bar are the cases in which the value of the corresponding parameter is not optimized for the scenario considered (because is taken as given). Tables 3.3 and 3.5 show the reduction in the loss function value (last column) that the optimal scenarios achieve (third column)

with respect to the baseline scenario (second column). Tables 3.2 and 3.3 present the results for the scenarios in which the macroprudential authority sets the optimal macroprudential policy given the national fiscal policies. Tables 3.4 and 3.5 present the results for the coordination between the optimal macroprudential and optimal fiscal policies scenarios.

I obtain a common result regarding the value and the minimization of the loss function, for all shocks described below and for both national and federal policies: the reduction in overall volatility is larger with optimal macroprudential and fiscal policy coordination (Table 3.5 implies a larger change in overall volatility than Table 3.3). This is due to the inclusion of an additional instrument in the optimal policy mix (fiscal policy), that not only stabilizes the fiscal objective variable but also helps macroprudential policy in the minimization of GDP and the financial indicator volatility.

The second step of the optimal policy analysis allows to evaluate the welfare gains or costs that the optimal policy scenarios entail. The results of the welfare-based comparison are presented in Table 3.6.[10]

As for the tables described above, for Table 3.6 the first row of each shock ("Home country LF") represents the scenarios in which the home national policy minimizes a home country loss function. The second row of each shock ("Foreign country LF") displays the scenarios in which the foreign national policy minimizes a foreign country loss function. The third row ("Union-wide LF") reports the scenarios in which federal macroprudential policy (sometimes together with national fiscal policies) minimizes a union-wide loss function.

I present the welfare cost in consumption equivalents following the methodology used in Schmitt-Grohé and Uribe (2004), Quint and Rabanal (2014) or Rubio and Carrasco-Gallego (2016), among others. Therefore, in Table 3.6, a positive value for consumption units represents a decrease in welfare in the optimal scenario with

[10]The welfare cost of the union as a whole is not provided in this table because it is very close to the home country welfare cost, due to the low effect on the foreign country welfare relative to that on the home country welfare.

respect to the baseline one. A negative value for consumption units represents a welfare gain with respect to the baseline scenario. Notice that in Table 3.6 the columns under *Optimal macroprudential policy* refer to the scenarios contained in Table 3.2 and the columns under *Optimal macroprudential and fiscal policy* to the scenarios contained in Table 3.4.

In line with Quint and Rabanal (2014), my analysis implies that, in the event of credit risk shocks, welfare increases with optimal macroprudential policy. Moreover, unlike Quint and Rabanal (2014), I analyze the situation of a spread shock and get the same results as for a credit risk shock regarding macroprudential policy and its ability to improve welfare. Thus, after financial shocks, macroprudential policy is effective not only for stabilization but also for welfare enhancing. Conversely, I find that in the event of supply and demand shocks, the optimal policy scenarios will, in general, decrease welfare (most of the figures of the second and fourth columns for the technology and preference shocks in Table 3.6 are positive).

Below, I proceed to analyze in detail each of the shocks.

3.7.1 Credit risk shocks

As shown in Chapter 2, when a credit risk shock hits the home country increasing the probability of default of home country entrepreneurs, the financial conditions to the home country private sector are toughened. Thus, private leverage goes down, decreasing investment and, consequently, GDP, what reduces the collection of taxes and raises public debt in the home country. This is how the private-public channel arises in the home country. In the event of these shocks, the findings in Chapter 1 and Chapter 2 prove that the cancellation of the channel leads to economic stabilization. The introduction of countercyclical national macroprudential measures in the home country offsets the channel (see Chapter 2). The main reason is that they directly target the home country's financial system, where the shock responsible for the private-public debt channel is originated.

Therefore, if the home country macroprudential authority aims at attaining financial

and economic stability, after this shock, the optimal value of γ_η implies a positive response to changes in the financial indicator. More concretely, the optimized values of γ_η are 2.07 (see Table 3.2) and 1.82 (see Table 3.4), respectively. This implies that home country macroprudential policy does not need to be very aggressive. A moderate response of the macroprudential parameter is enough to stabilize private debt, through which the effects of this shock are transmitted to the broader economy.

In the event of credit risk shocks, a low value of γ_η^* characterizes the optimal foreign macroprudential policy when it interacts with optimal fiscal policy ($\gamma_\eta^* = 1.04$). However, optimal foreign macroprudential policy is more aggressive when it is the only one minimizing the corresponding loss function ($\gamma_\eta^* = 5.00$ in second row of Table 3.2). This result is consistent with Chapter 2 that proves that after financial shocks originated in the home country a moderate foreign macroprudential policy ($\gamma_\eta^* = 1.75$) by itself barely affects the main variables of any of the countries. Actually, Chapter 2 shows that the effects of this moderate foreign macroprudential policy are equivalent to a no macroprudential policy scenario in both countries. The reason is that, in the event of a credit risk shock originated in the home country, economic destabilization within the currency area comes from the home country private-public debt channel which is not directly addressed by foreign macroprudential policy. Thus, it is hard for foreign macroprudential policy to stabilize the economy in the case of these shocks. This explains why optimal foreign macroprudential policy devolves to foreign fiscal policy when the latter, that can do best, aims at economic stabilization. But, on the other hand, if optimal foreign macroprudential policy is left alone, as this measure is not as effective as others in stabilizing the economy, γ_η^* needs to be as high as possible.

The optimal response of federal macroprudential policy is closed to the one implied by the optimal home country national macroprudential policy ($\gamma_\eta = 1.89$ and $\gamma_\eta = 2.46$ in Tables 3.2 and 3.4, respectively). The similarity between the optimal home country national and the federal response to the financial indicator is a consequence of the similarity between the home and the union-wide loss functions. The latter is mainly affected by the volatility of the home variables that fluctuate more than

the foreign variables, due to the origin (home country) of the shock considered. However, this federal policy implies the most aggressive response to foreign financial variables to compensate in the federal macroprudential rule the easing response that the home financial system requires ($\gamma_\eta^* = 5.00$ in both Tables 3.2 and 3.4).

Therefore I find, as so do Quint and Rabanal (2014), that when credit risk shocks hit the home country economy, the optimal macroprudential policy always needs to respond to financial variables in order to offset the effects of the shock (all the optimal scenarios imply a positive value for the macroprudential parameters, γ_η and γ_η^*).

The optimal fiscal policy in the home country (see the last two columns of Table 3.4), is always characterized by $d_g = -0.09$, the lower bound in the analysis, independently of the loss function it aims at minimizing. This corresponds to the most passive fiscal policy that is possible to set given the limits imposed. For the optimal foreign fiscal policy the results also imply the most passive response of fiscal policy, $d_g^* = -0.09$.

The introduction of public debt volatility in the loss function of scenarios of Table 3.4 is responsible for the very passive optimal fiscal policy in both countries, given that monetary policy is active and thus it does not contribute to the government debt stabilization. This is accentuated by the fact that both home and foreign public debt are highly destabilized after a credit risk shock so the response of the fiscal instrument should be aggressive to attain stability.

After credit risk shock, the welfare cost in the home country is always negative, what means that the home country welfare will increase under all optimal macroprudential policy scenarios (see the second and fourth columns for the credit risk shock of Table 3.6). Moreover, home country welfare gains are greater when macroprudential policy is implemented at the home country level than when a supranational authority sets a federal macroprudential policy (compare the first and third rows for the credit risk shocks in Table 3.6). The welfare gains for the home country from the implementation of foreign macroprudential policy are quite insignificant (0.000% or

-0.001%). This is consistent with Chapter 2 which shows that the effects of foreign macroprudential policy in the home country are the same of the no macroprudential case. The home country welfare improvement implied by macroprudential policy under this shock is a consequence of the stabilization in the financial system that entails a lower fall of GDP or even a GDP growth, compared to the baseline scenario. These results are in line with Quint and Rabanal (2014), as they explain that macroprudential policy leaning against the wind of credit cycles improves welfare under risk shocks.

The effects of the optimal scenarios on foreign country welfare are also positive (see the negative figures in the third and fifth columns for the credit risk shock in Table 3.6). If macroprudential policy is implemented by the home country, the growth in home GDP and inflation imply an interest rate increase that affects the financial system of the foreign country. Foreign private debt falls and with it investment and output. The fall in foreign GDP leads to a labor decrease that is deeper than the decrease implied for private consumption. If, by contrast a restrictive macroprudential policy is set by the foreign country, then the foreign financial system will be directly stabilized. Foreign GDP will continue growing but at a more stable rate and therefore foreign labor will not need to increase as much as in the baseline case. Thus, the net effect in foreign welfare of optimal national macroprudential policy is positive.

Regarding the welfare effects of optimal fiscal-macroprudential coordination, the home country has more welfare gains when optimal national macroprudential and fiscal policies coordinate (-0.029% versus -0.027%, respectively). However, for the federal macroprudential case, welfare gains for the home country are larger when there is no coordination with fiscal policies (-0.009% versus -0.008%, respectively). The situations that increase welfare under this shock imply a higher increase or lower decrease in government spending and therefore a higher level of GDP.

3.7.2 Spread shocks

After a positive spread shock in the home country, the intermediation costs assumed by the domestic financial intermediary increase, what raises the cost of funds to be lent to entrepreneurs. As a consequence, home country private debt goes down decreasing private investment and output and, as tax revenues fall, public debt increases in the home country. Thus, in the case of this shock, the private-public debt channel is present in the home country. However, although the introduction of a national macroprudential policy in the home country does not manage to cancel the channel, it attains economic stability. This is because the transmission of this shock from the financial sector to the broader economy is stronger than under financial credit risk shocks. The reason for this is that a rise in the spread costs implies a more persistent fall of networth, relative to that of private debt, than the rise in credit risk. This contributes to a similar fall of investment and GDP, although private debt does not decrease that much as in the event of a credit risk shock. Following the findings in Chapter 2, less destabilization of the financial system than the one produced by a credit risk shock, implies a similar economic destabilization. In other words, this kind of financial shock destabilizes GDP and public leverage more than the credit risk shock, relative to the destabilization suffered by private debt.

Therefore, regarding the optimal macroprudential policy in the home country, the value of γ_η always implies the most aggressive response of macroprudential policy to changes in the financial indicator, that is $\gamma_\eta = 5.00$ (see Tables 3.2 and 3.4). As explained before, a moderate destabilization of the home country private debt implies a high destabilization of GDP and public debt in the home country. Thus, national macroprudential policy in the home country should react strongly to changes in the financial indicator to ensure that private debt is stabilized and with it the rest of the economy.

In the foreign country, private debt and output are almost isolated from the effects of the home country spread shock, as opposed to public debt. Therefore, the op-

timal foreign macroprudential policy is a zero response to changes in the financial indicator when it minimizes a loss function that only considers foreign country output and private debt. However, when foreign public debt is introduced in the loss function, foreign macroprudential policy "lends a hand" to the corresponding policy that directly targets this new variable, concretely, $\gamma_\eta^* = 1.07$ (see Table 3.4).

To minimize the aggregate loss function, the optimal response of federal macroprudential policy is as aggressive as possible ($\gamma_\eta = 5.00$ and $\gamma_\eta^* = 5.00$ in Tables 3.2 and 3.4). The optimal federal response to home country financial conditions coincide with the one of national home macroprudential policy because, the union-wide loss function is mainly affected by the volatility of the home country's variables. As in the case of a credit risk shock, the federal response to the foreign financial indicator is so aggressive ($\gamma_\eta^* = 5.00$) to compensate in the federal macroprudential rule the easing response that the home financial system requires.

For the optimal fiscal policy (last two columns of Table 3.4), the optimal value of d_g is again always -0.09, the lower bound. The high public debt volatility is the reason why the optimal home country fiscal policy is as passive as possible. In the foreign country, the optimal value of d_g^* is also quite aggressive, although is less negative than d_g when it minimizes a loss function of union-aggregate variables. The reason is that the volatility of home government debt is higher than that of foreign government debt, so a lower response of d_g^* is needed to stabilize the aggregate union-wide public leverage.

Regarding the effects on home and foreign welfare of the optimal scenarios computed for a spread shock I obtain the same results to that implied by a credit risk shock. This allows me to conclude that welfare increases with optimal macroprudential policy in the event of financial shocks in general. The reason is that macroprudential policy directly stabilizes the financial system variables, through which the effects of financial shocks are transmitted to the broader economy.

For the particular case of spread shocks, optimal fiscal policy does not affect home country welfare in any of the scenarios analyzed (the figures for the spread shock

are the same in the second and fourth columns in Table 3.6). The foreign country's welfare is not affected by the optimal macroprudential-fiscal policy coordination in the event of any of the considered financial shocks. In this situations, the scenarios of higher increase or lower decrease in government spending and GDP are compensated with a higher levels of labor or lower consumption, what maintains welfare unchanged.

3.7.3 Technology shocks

When the economy of the home country is hit by a positive technology shock, the level of home country output directly increases. Then, as a consequence of a rise in tax collection, public debt goes down in the home country. At the same time, the level of prices goes down as aggregate supply increases and, therefore, the intervention rate also falls. This reduces other interest rates of the financial system so the rate on loans decreases improving financial conditions to entrepreneurs. But, under this shock, private debt is barely destabilized, even if the amount of home country loans increases after the shock and therefore the private-public debt channel arises in the home country.

The optimal national home macroprudential policy always entails $\gamma_\eta = 5.00$ (Tables 3.2 and 3.4). This is the upper bound and the most aggressive response to changes in the financial indicator that home country macroprudential policy can set. As in the case explained before, given that private debt is hardly destabilized, this aggressive home country macroprudential policy is necessary to affect the latter. An even smoother increase of private debt, compared to the baseline scenario, slows private investment and ensures GDP stabilization in the home country.

The optimal foreign macroprudential policy consists of a zero response to the financial indicator in the absence of cooperation with fiscal authority (row 8 of Table 3.2). The reason is that in this scenario the loss function only includes the volatility of the foreign financial indicator and GDP, which remain considerably stable after the shock. However, the optimized value of the foreign macroprudential parameter is $\gamma_\eta^* = 2.05$ in the case in which foreign public debt is included in the loss function.

This time, optimal foreign macroprudential policy is not only in charge of private debt stability but also shares the public debt stability objective with foreign fiscal policy.

The optimal federal macroprudential policy implies the most aggressive response to home financial variables, ($\gamma_\eta = 5.00$ in row 9 of Tables 3.2 and 3.4). As in the previous cases, the equality of the optimal home national macroprudential parameter and the optimal federal value for γ_η is due to the similarity between the home country and the union-wide loss functions. The optimal federal macroprudential responses to financial variables in the foreign country imply $\gamma_\eta^* = 1.98$ and $\gamma_\eta^* = 1.11$ for the non-coordintation and coordination case, respectively. The low destabilization suffered by the foreign financial indicator under this technology shock causes this moderate response.

In the event of technology shocks, the destabilization of both home and foreign public debt requires that the optimal values of d_g and d_g^* are always -0.09, the lower bound considered in this analysis. The high home and foreign public debt destabilization that this shock involves is the main reason for the latter. Foreign public debt is destabilized due to the international financial market that affects the rate on foreign deposits, taxed in this model. Proportional taxes play their corresponding role in the fluctuation of foreign public debt.

When a supply shock hits the home economy, a home country macroprudential policy that targets the growth of national nominal credit will restrict the amount of loans to the private sector. So the rate on loans goes up to restrain private leverage and investment, slowing GDP growth. Therefore, in line with Quint and Rabanal (2014), I observe that macroprudential policy reduces home country welfare under technology shocks due to an increase in the countercyclicality of the lending-deposit spread. By contrast, foreign welfare will increase, in the national and federal macroprudential scenarios, except for the cases in which the foreign country does not implement macroprudential policy (0.024% and 0.029%). The restrictive home country macroprudential policy reduces the foreign country welfare in the following way. Due to the international financial market, there is a capital flight from the

home country to the foreign country what increases foreign private leverage and investment. This implies a growth of output and labor what hurts foreign country welfare. However, a restrictive federal or foreign national macroprudential policy (when it is set coordinately with optimal foreign fiscal policy) will slow foreign private investment and output. As a consequence, foreign labor falls deeper than in the baseline scenario, thus increasing foreign welfare (-0.032% and -0.031% in the federal macroprudential case and -0.020% when optimal foreign national macroprudential and fiscal policy interact).

The optimal fiscal-macroprudential coordination implies better welfare results than if optimal macroprudential policy is set individually (compare the second and fourth columns for the technology shock in Table 3.6). Again, this is because, under technology shocks, the optimal fiscal policy implies higher levels of government spending and output.

3.7.4 Preference shocks

Finally, I consider the case of a preference (or demand) shock in the home country economy. This shock increases consumption as a consequence of a change in the consumer's preferences. Then output increases on impact and, with it, public revenues, so public leverage also goes down on impact. The initial growth in aggregate demand raises inflation and the intervention rate. This rise is transmitted to other interest rates of the financial system, such as the rate on loans. Thus private debt decreases in the home country and the private-public debt channel is not present in the event of this demand shock. The effect of the financial system is transmitted to the real economy by a deep fall in home country private investment. This provokes a sharp fall in GDP, after the initial rise, and makes public debt start to go up, thus extremely destabilizing both variables. Public debt is more destabilized than private debt in both countries of the currency area, as the effect of the shock is transmitted to the public sector directly through proportional taxes.

The home country sets a quite aggressive optimal macroprudential policy implying $\gamma_\eta = 3.03$ when it only aims at stabilizing private debt, and $\gamma_\eta = 5.00$ when it also

aims at public debt stability. Such aggressive values of parameter γ_η are necessary to stabilize private debt and, therefore, to affect the hugely destabilized private investment. Home country macroprudential policy eases the fall in private debt what contributes to a smooth increase in investment. Due to this optimal home macroprudential policy, home country GDP does not decrease as much as in the baseline scenario.

As mentioned previously, the initial increase in home aggregate demand raises prices in the home country. Therefore, the terms of trade decrease allowing foreign goods to be more competitive. As home country consumption goes up, a decrease in home country net exports generates a growth of foreign GDP. In Chapter 1 I call this effect the *open economy channel*. At the same time, foreign private investment and consumption decrease compensating the rise in foreign aggregate demand. This explains why when the home country economy is hit by preference shocks there is no situation in which a foreign macroprudential policy reduces the objective loss function ($\gamma_\eta^* = 0.00$ for this shock in both Tables 3.2 and 3.4). The introduction of foreign macroprudential policy stabilizes the fall of foreign private debt and investment but then, it accentuates the increase in GDP and the fall in public leverage, destabilizing both variables.

When foreign public debt is an objective variable of the loss function, optimal fiscal policy manages to stabilize it by itself, allowing foreign macroprudential policy to maintain a zero response. In line with this, the optimal federal macroprudential policy responds aggressively to changes in credit market conditions ($\gamma_\eta = 5.00$ and $\gamma_\eta^* = 5.00$) if it is the only instrument in charge of the union-wide GDP stabilization. But when fiscal and macroprudential measures interact in the optimal policy mix, the union macroeconomic stability is attained through fiscal policy only and $\gamma_\eta = 0.00$ and $\gamma_\eta^* = 0.00$. This ensures that federal macroprudential policy does not destabilize the union, under this home country demand shock, as in the optimal foreign macroprudential scenario.

The optimal fiscal policy again implies the most aggressive value for d_g, that is -0.09, which is the lower bound and a quite aggressive value for d_g^* (see Table 3.4). The

high volatility of public debt under this shock, together with an active monetary policy, is the main cause for the very passive optimal fiscal policy.

After a demand shock in the home country, a home country macroprudential policy that targets the national nominal credit growth, eases the financial conditions to the private sector. To that aim, it encourages the amount of loans to be lent by home financial intermediaries. This generates an increase in private investment and GDP in the home country. As a consequence, labor goes up, what reduces the households' welfare, especially considering that this shock reduces their preferences for labor relative to consumption. Moreover, private consumption in the home country is not affected by this macroprudential policy. Thus, the GDP increase, that this home macroprudential policy implies, leads to a decrease in home country welfare. My results coincide with the statement of Quint and Rabanal (2014) that a macroprudential policy which magnifies the countercyclicality of the lending-deposit spread reduces welfare. However, as opposed to Quint and Rabanal (2014), I find an increase in the countercyclicality of the lending-deposit spread after preference shocks. The main reason for my results is that I analyze an increase in the (non-durable) consumption preference shock relative to labor, while they consider an increase in durables preference shock. Therefore, optimal macroprudential policy in my analysis, in general hurts home country welfare after preference shocks.

The foreign country will only improve welfare when there is optimal fiscal policy but no macroprudential policy in place (notice that the negative figures for the foreign country welfare cost in the preference shock of Table 3.6 correspond to scenarios of zero response of macroprudential policy). The latter proves that macroprudential policy is not very effective for welfare objectives under demand shocks. Moreover, this provides a rationale for the introduction of fiscal policy in the optimal policy mix analysis (as opposed to what is done in Quint and Rabanal, 2014), as after certain shocks, it may be the only tool that authorities can use to enhance welfare.

In the event of this preference shock, home country welfare is improved in the absence of optimal macroprudential and fiscal coordination (0.070% versus 0.098% when macroprudential policy is set at the national level and -0.002% versus 0.025%

when macroprudential policy is set at the union level). The reason is that, under this shock, the higher levels of GDP, implied by the optimal fiscal policy, generate higher levels of home country labor. But the coordination scenario positively affects foreign welfare after demand shocks (-0.002% versus 0.000% when macroprudential policy is set at the national level and -0.004% versus 0.002% when macroprudential policy is set at the union level). This is because coordination in this case increases foreign government consumption and, with it, foreign GDP.

3.8 Conclusion

In this chapter I perform a normative analysis to evaluate the stabilization properties and welfare implications of an optimal policy mix in which macroprudential and fiscal policies interact. With this aim I use a two-country DSGE model for a monetary union and assume that shocks are originated in one of the countries while the other country indirectly suffers the consequences.

The optimal policy mix results differ across countries and depend on the shock that drives the business cycle fluctuations. First, the optimal macroprudential response can be either very aggressive or zero in the different scenarios considered. What I conclude is that in the event of a credit risk shock, the optimal policy mix will always require a macroprudential response to changes in financial variables, in order to restore stability by offsetting the effects of the shock in the financial system.

Secondly, in terms of volatility minimization, optimal macroprudential policy works better when it interacts with fiscal policy, no matter what shock hits the home country economy. However, the effects of each optimal scenario on welfare depend strongly on the shock considered and not on the interaction between optimal fiscal and macroprudential policies.

Finally, the optimal macroprudential and fiscal policies affect each country's welfare differently. When the economy is hit by a financial shock, the optimal policy scenario that improves the home country welfare the most is the one that implements national macroprudential policy in the home country. This optimal scenario also

maximizes foreign country welfare if the shock is a credit risk shock, however, when considering a financial spread shock the largest foreign country welfare is obtained under federal macroprudential policy. After a technology shock, the home country welfare improves only when the foreign country implements optimal national macroprudential and fiscal policies coordinately. Regarding the foreign country welfare, the federal macroprudential scenarios are the ones that improve it the case of technology shocks. Under a preference shock the best optimal macroprudential scenario for both countries' welfare is the one where federal macroprudential policy is implemented without coordinating with fiscal policy.

Thus, the desirability of implementing macroprudential policy, for loss function minimization and welfare enhancing, is beyond argument under financial shocks but not under supply and demand shocks. However, the best policy mix in terms of volatility minimization is not always the best one in terms of welfare improvement. Moreover, the best scenario for the home country welfare does not always coincide with the best scenario for the foreign country welfare. Policymakers that want to implement the optimal macroprudential policy strategy should consider not only their stabilization or welfare objectives but also the source of the shock that hits the economy.

Some interesting issues, to be addressed in future work, derive from this paper. First of all, my analysis takes monetary policy as given and finds the optimal fiscal and macroprudential policies. In further research, it could be interesting to add monetary policy as part of the optimal policy mix to evaluate the effects on stabilization and welfare when the three policies interact. Another area that should be covered is the analysis of alternative optimal macroprudential instruments, for instance, one targeting the credit-to-GDP ratio as in Chapter 1. Finally, alternative optimal fiscal rules, such as different tax rules, could be also considered. These two last analysis will allow to assess what design of macroprudential policy or what type of fiscal rule is more optimal, depending on the shock that hits the economy.

Tables

Table 3.1: Calibration of the parameters and steady states for Chapter 3

Parameter	**Description**	**Value**	**Source**
β	Discount factor	0.999	Fernández-Villaverde (2010)
h	Consumption habits	0.5	Fernández-Villaverde (2010)
n	Size of the home country	0.5	Faia (2001)
$\frac{c_F}{y}$	Imports from the foreign country-to-GDP	0.1	Own calibration to obtain a ratio $\frac{\bar{B}}{y} = 1.88$
$\frac{c_H^*}{y^*}$	Exports to the foreign country-to-GDP	0.11	Own calibration to obtain a ratio $\frac{\bar{B}}{y} = 1.88$
ζ	Substitutability between domestic and foreign goods	1.5	Faia (2001)
Ω	Debt elasticity of the country premium	0.0043	Quint and Rabanal (2014)
t	Steady state value for the terms of trade	1	Faia (2001)
ϑ	Frisch elasticity of labor	0.5	Fernández-Villaverde (2010)
α	Capital share of the intermediate production function	0.33	Fernández-Villaverde (2012)
δ	Capital depreciation rate	0.023	Fernández-Villaverde (2012)
θ	Calvo pricing parameter	0.8	Fernández-Villaverde (2010)
ε	Elasticity of substitution across goods	8.577	Fernández-Villaverde (2012)
χ	Degree of indexation	0.6	Fernández-Villaverde (2010)
$pdef$	Annual probability of default	0.03	Bernanke et al. (1999)

Parameter	**Description**	**Value**	**Source**
μ	Bankruptcy costs	0.15	Fernández-Villaverde (2012)
$s = s^*$	Average spread	1.0025	Fernández-Villaverde (2012)
$\bar{\gamma}^e = \bar{\gamma}^{e*}$	Entrepreneurs exit coefficient	3.67	Fernández-Villaverde (2010)
$\tau_l = \tau_l^*$	Steady state of labor income tax rate	0.24	Fernández-Villaverde (2010)
$\tau_r = \tau_r^*$	Steady state of capital income tax rate	0.42	Own calibration to obtain a ratio $\frac{\bar{B}}{y}$ of 1.88
$\Pi = \Pi^* = \Pi_H = \Pi_F$	Target gross inflation	1.005	Fernández-Villaverde (2010)
$l = l^*$	Time devoted to work	1/3	Fernández-Villaverde (2010)
$q = q^*$	Tobin's q. Price of capital	1	Fernández-Villaverde (2010)
R^d	Steady state of interest rate on home public debt	$\frac{\Pi}{\beta}$	Fernández-Villaverde (2010)
R	Steady state of interest rate on home deposits	$\frac{R^d-1}{1-\tau_R}+1$	Fernández-Villaverde (2010)
R^{d*}	Steady state of interest rate on foreign public debt	$\frac{\Pi^*}{\beta}$	Fernández-Villaverde (2010)
R^*	Steady state of interest rate on foreign deposits	$\frac{R^{d*}-1}{1-\tau_R^*}+1$	Fernández-Villaverde (2010)
$\frac{\bar{b}}{k} = \frac{\bar{b}^*}{k^*}$	Loan-to-capital ratio	1/3	Fernández-Villaverde (2010)
$\frac{g}{y} = \frac{g^*}{y^*}$	Government expenditure-to-GDP ratio	0.2	Gomes and Seoane (2018)
$\frac{d}{y} = \frac{d^*}{y^*}$	Public debt-to-GDP ratio	0.6	Gomes and Seoane (2018)

Parameter	**Description**	**Value**	**Source**
$S^{"}$ [1]	Capital adjustment costs	14.477	Fernández-Villaverde (2012)
ρ_{ϕ}	Persistence of preference shock	0.95	Fernández-Villaverde (2012)
σ_{ϕ}	Volatility of preference shock	0.032	Gomes and Seoane (2018)
ρ_{s}	Persistence of spread shock	0.95	Fernández-Villaverde (2012)
σ_{s}	Volatility of spread shock	0.3058	Own estimation
γ_{g}	Persistence parameter of government spending shock	0.95	Fernández-Villaverde (2012)
σ_{g}	Volatility of government spending shock	0.007	Gomes and Seoane (2018)
ρ_{z}	Persistence of technology shock	0.95	Fernández-Villaverde (2012)
σ_{z}	Volatility of technology shock	0.025	Gomes and Seoane (2018)
ρ_{σ}	Persistence of credit risk shock	0.95	Fernández-Villaverde (2012)
η_{σ}	Volatility of credit risk shock	0.074	Christiano, Motto and Rostagno (2010)
γ_{R}	Persistence of monetary policy shock	0.95	Fernández-Villaverde (2012)
σ_{m}	Volatility of monetary policy shock	0.003	Gomes and Seoane (2018)
$\gamma_{\Pi}\left(1-\gamma_{R}\right)$	Response of intervention rate to changes in inflation	1.5	Fernández-Villaverde (2012)
d_{g}	Response of government spending to changes in public debt	-0.01	Own calibration

Parameter	**Description**	**Value**	**Source**
d_g^*	Response of foreign government spending to changes in foreign public debt	-0.01	Own calibration
$\gamma_\eta = \gamma_\eta^*$	Response of macroprudential tool to changes in credit market conditions	0 or 1.75	Own calibration
$\eta = \eta^*$	Steady state value of macroprudential instrument	1	Quint and Rabanal (2014)

Table 3.2: Optimal macroprudential policy

MINIMIZATION OBJECTIVE OF THE OPTIMAL POLICY	γ_η	γ_η^*
Credit risk shock in home country		
Home country LF	2.07	-
Foreign country LF	-	5.00
Union-wide LF	1.89	5.00
Spread shock in home country		
Home country LF	5.00	-
Foreign country LF	-	0.00
Union-wide LF	5.00	5.00
Technology shock in home country		
Home country LF	5.00	-
Foreign country LF	-	0.00
Union-wide LF	5.00	1.98
Preference shock in home country		
Home country LF	3.03	-
Foreign country LF	-	0.00
Union-wide LF	5.00	5.00

Note: The first rows of each shock represent the home national macroprudential policy that aims at minimizing a home country loss function. The second rows of each shock represent the foreign national macroprudential policy that aims at minimizing a foreign country loss function. The third rows of each shock represent the federal macroprudential policy that aims at minimizing the union-wide loss function. Cells containing a horizontal bar are cases in which the value of the corresponding parameter is not optimized for the scenario considered (because is taken as given).

Table 3.3: Loss function for alternative scenarios of optimal macroprudential policy

MINIMIZATION OBJECTIVE OF THE OPTIMAL POLICY	Loss function value of baseline scenario	Loss function value of optimal scenario	Change in overall volatility
Credit risk shock in home country			
Home country LF	0.000091	0.000063	-31.08%
Foreign country LF	0.0000006	0.0000005	-16.74%
Union-wide LF	0.000022	0.000007	-66.93%
Spread shock in home country			
Home country LF	0.000027	0.000010	-64.55%
Foreign country LF	0.0000002	0.0000002	0.00%
Union-wide LF	0.000006	0.000002	-63.12%
Technology shock in home country			
Home country LF	0.00327	0.00216	-33.97%
Foreign country LF	0.00005	0.00005	0.00%
Union-wide LF	0.00101	0.00069	-31.13%
Preference shock in home country			
Home country LF	0.00011	0.00006	-50.07%
Foreign country LF	0.00002	0.00002	0.00%
Union-wide LF	0.00005	0.00004	-28.20%

Note: The last column of the table is the variation between the two previous columns. The first rows of each shock represent the home national macroprudential policy that aims at minimizing a home country loss function. The second rows of each shock represent the foreign national macroprudential policy that aims at minimizing a foreign country loss function. The third rows of each shock represent the federal macroprudential policy that aims at minimizing the union-wide loss function.

Table 3.4: Optimal macroprudential and fiscal policy

MINIMIZATION OBJECTIVE OF THE OPTIMAL POLICY	γ_η	γ_η^*	d_g	d_g^*
Credit risk shock in home country				
Home country LF	1.82	-	-0.09	-
Foreign country LF	-	1.04	-	-0.09
Union-wide LF	2.56	5.00	-0.09	-0.09
Spread shock in home country				
Home country LF	5.00	-	-0.09	-
Foreign country LF	-	1.07	-	-0.09
Union-wide LF	5.00	5.00	-0.09	-0.08
Technology shock in home country				
Home country LF	5.00	-	-0.09	-
Foreign country LF	-	2.05	-	-0.09
Union-wide LF	5.00	1.11	-0.09	-0.09
Preference shock in home country				
Home country LF	5.00	-	-0.09	-
Foreign country LF	-	0.00	-	-0.09
Union-wide LF	0.00	0.00	-0.09	-0.06

Note: The first rows of each shock represent the home national macroprudential and fiscal policies that aim at minimizing a home country loss function. The second rows of each shock represent the foreign national macroprudential and fiscal policies that aim at minimizing a foreign country loss function. The third rows of each shock represent the federal macroprudential policy and both countries' national fiscal policies that aim at minimizing the union-wide loss function. Cells containing a horizontal bar are cases in which the value of the corresponding parameter is not optimized for the scenario considered (because is taken as given).

Table 3.5: Loss function for alternative scenarios of optimal macroprudential and fiscal policy

MINIMIZATION OBJECTIVE OF THE OPTIMAL POLICY	Loss function value of baseline scenario	Loss function value of optimal scenario	Change in overall volatility
Credit risk shock in home country			
Home country LF	0.00536	0.00026	-95.14%
Foreign country LF	0.00033	0.00012	-64.83%
Union-wide LF	0.00185	0.00002	-98.83%
Spread shock in home country			
Home country LF	0.00154	0.00003	-98.04%
Foreign country LF	0.00009	0.00003	-70.32%
Union-wide LF	0.00055	0.00001	-98.64%
Technology shock in home country			
Home country LF	0.21547	0.01445	-93.29%
Foreign country LF	0.00394	0.00079	-79.95%
Union-wide LF	0.04221	0.00212	-94.97%
Preference shock in home country			
Home country LF	0.03043	0.00241	-92.09%
Foreign country LF	0.01278	0.00110	-91.37%
Union-wide LF	0.00216	0.00030	-85.90%

Note: The last column of the table is the variation between the two previous columns. The first rows of each shock represent the home national macroprudential and fiscal policies that aim at minimizing a home country loss function. The second rows of each shock represent the foreign national macroprudential and fiscal policies that aim at minimizing a foreign country loss function. The third rows of each shock represent the federal macroprudential policy and both countries' national fiscal policies that aim at minimizing the union-wide loss function.

Table 3.6: Welfare costs in consumption equivalents

	Optimal MaP only		Optimal Map and fiscal	
MINIMIZATION OBJECTIVE OF THE OPTIMAL POLICY	Home country welfare cost	Foreign country welfare cost	Home country welfare cost	Foreign country welfare cost
Credit risk shock in home country				
Home country LF	-0.027%	-0.003%	-0.029%	-0.003%
Foreign country LF	-0.001%	-0.001%	0.000%	0.000%
Union-wide LF	-0.009%	0.001%	-0.008%	0.003%
Spread shock in home country				
Home country LF	-0.023%	-0.004%	-0.023%	-0.004%
Foreign country LF	0.000%	0.000%	0.000%	0.000%
Union-wide LF	-0.013%	-0.008%	-0.013%	-0.008%
Technology shock in home country				
Home country LF	0.128%	0.024%	0.118%	0.029%
Foreign country LF	0.000%	0.000%	-0.002%	-0.020%
Union-wide LF	0.037%	-0.032%	0.028%	-0.031%
Preference shock in home country				
Home country LF	0.070%	0.007%	0.098%	0.007%
Foreign country LF	0.000%	0.000%	0.000%	-0.002%
Union-wide LF	-0.002%	0.002%	0.025%	-0.004%

Note: The columns under *Optimal macroprudential policy* refer to the scenarios where optimal macroprudential policy is set given a fiscal policy, that is, scenarios contained in Table 3.2. The columns under *Optimal macroprudential and fiscal policy* refer to the scenarios where optimal macroprudential policy is set together with optimal fiscal policy, that is, scenarios contained in Table 3.4. The first rows of each shock represent the home national policies minimizing a home country loss function; the second rows the foreign national policies minimizing a foreign country loss function; the third rows the federal macroprudential, and both countries' national fiscal policies in the last two columns, minimizing the union-wide loss function.

Conclusions and future research

This doctoral dissertation, on the one hand, complements the findings of the previous literature and, on the other hand, establishes an analysis framework for future studies related to macroprudential policy.

The first relevant conclusion is that, after a financial shock, is useful to introduce macroprudential policy as part of the policy mix because traditional policies cannot stabilize by themselves the financial sector and the rest of the economy. When macroprudential policy is included it is possible to stabilize public debt and private debt at the same time, offsetting the destabilizing private-public debt channel that arises after this type of shocks.

Moreover, when the financial indicator to which macroprudential policy reacts is the nominal private credit growth, a greater macroeconomic stability is reached and financial stabilization is also achieved. The latter is consistent with the ESRB recommendation that indicates that one of the intermediate objectives of macroprudential policy should be the control of excessive credit growth.

Secondly, the interaction between macroprudential policy and fiscal policy becomes particularly relevant especially in the context of a monetary union where the countries cannot set their own monetary policy. This research considers an asymmetric shock in the monetary union, meaning that it does not affect all members in the same way as it is originated in one country of the union and the others suffer its consequences. The macroprudential policy implementation that benefits the most all members of a monetary union is the one that is undertaken at the national level, so that each country can face its own fluctuations by using this instrument.

However, the part of the union that is responsible for the shock affecting the economy can obtain benefits from a macroprudential policy implemented at the union level. Nevertheless, this scenario harms the country where the financial shock is not originated.

Finally, the normative analysis included in this research allows us to conclude that in the event of supply and demand shocks the introduction of macroprudential policy does not always achieve economic stabilization or welfare improvement. However, when a financial shock hits the economy, the optimal policy mix always includes the use of macroprudential policy, whether the authorities aim at increasing welfare or attaining economic stabilization.

All in all, through this dissertation I find that, after a financial shock, macroprudential policy manages to affect the financial system. This way it complements the traditional policies in the pursue of economic stabilization, both in the context of a closed economy or in a monetary union.

My dissertation opens the door to a wide range of possible analysis for future work. The main area required to be covered is an empirical study to complement the results obtained in this doctoral thesis. The model could be estimated for different countries of the EMU, such as Germany (representing the core) and Spain (representing the periphery). A second promising research, which derives from my study, is to compare the effectiveness of macroprudential policy as a stabilization tool for the different phases of the cycle. As explained by Cerutti et al. (2015), macroprudential policy works better in booms than in busts, so it could be interesting to analyze a macroprudential rule adapting its degree of responsiveness to the business cycle needs. Finally, further research could go in the direction of introducing in the model either alternative macroprudential instruments or alternative fiscal rules, such as a tax rule. This would confirm the robustness of the results obtained in the positive and normative analysis of my dissertation.

Conclusiones y futura investigación (Spanish)

Esta tesis doctoral, por un lado, complementa los resultados de la literatura anterior y, por otro lado, establece un marco de análisis para futuras investigaciones relacionadas con la política macroprudencial.

La primera conclusión relevante es que, tras una perturbación financiera, es útil introducir la política macroprudencial como parte del conjunto de políticas económicas ya que las políticas tradicionales no son capaces de estabilizar, por sí mismas, el sector financiero y el resto de la economía. Al incluir la política macroprudencial es posible estabilizar las deudas privada y pública al mismo tiempo, cancelando el desestabilizador canal de deuda privada-pública que aflora tras estas perturbaciones.

Además, si el indicador financiero al que responde la política macroprudencial es el crecimiento del crédito privado nominal, se logra una mayor estabilidad no macroeconómica y alcanzando también la estabilidad financiera. Esto último es consistente con la recomendación del ESRB que indica que uno de los objetivos intermedios de la política macroprudencial debe ser el control del crecimiento excesivo del crédito.

En segundo lugar, la interacción entre la política macroprudencial y la política fiscal adquiere una especial importancia. sobretodo en el ámbito de una unión monetaria donde los países no pueden utilizar su propia política monetaria. Esta investigación considera una perturbación asimétrica en la unión monetaria, es decir, que no afecta a todos los miembros por igual ya que se origina solo en un país de la unión y el otro sufre las consecuencias de la misma. La implementación de política macroprudencial

que más beneficia a todos los miembros de la unión es aquella que se realiza a nivel nacional, de manera que cada país puede hacer frente a sus propias fluctuaciones a través de este instrumento. Sin embargo, la parte de la unión monetaria responsable de la perturbación que afecta a la economía puede verse beneficiada por la política macroprudencial implementada a nivel de la unión. Sin embargo este escenario perjudica al país en el que no tiene origen la perturbación financiera.

Por último, el análisis normativo incluido en esta investigación, permite concluir que, ante perturbaciones de oferta y de demanda, la introducción de la política macroprudencial no siempre consigue la estabilización económica ni la mejora del bienestar. Sin embargo, tras una perturbación financiera, la combinación óptima de políticas siempre incluye el uso de la política macroprudencial, tanto si las autoridades buscan aumentar el bienestar como si persiguen la estabilización económica.

De manera general, mediante de esta tesis doctoral, se muestra que, tras una perturbación financiera, la política macroprudencial consigue afectar al sector financiero. Así complementa a las políticas tradicionales en la búsqueda de la estabilización económica, tanto en el contexto de economía cerrada como de una unión monetaria.

Mi investigación abre la puerta a un amplio rango de posibles análisis para trabajos futuros. La principal área que se necesita cubrir es un estudio empírico que complemente los resultados obtenidos en esta tesis doctoral. Se podría estimar el model para diferentes países de la EMU, tales como Alemania (representando el núcleo) y España (representando la periferia). Otra segunda investigación prometedora, que deriva de mi estudio, es comparar la efectividad de la política macroprudencial como herramienta estabilizadora en las diferentes fases del ciclo. Tal y como explican Cerutti et al. (2015), la política macroprudencial funciona mejor en booms económicos que en recesiones, por lo que puede ser interesante analizar una regla macroprudencial que adapte su grado de respuesta a la necesidad del ciclo económico. Finalmente, investigaciones futuras pueden ir en la dirección de introducir en el modelo bien instrumentos macroprudenciales alternativos o bien reglas fiscales alternativas, como una regla impositiva. Esto confirmaría la robustez de los resultados obtenidos en los análisis positivo y normativo de mi tesis doctoral.

Appendix A

Data

Data for Spain, the US and Germany cover the period 1960-2017 for the main series of interest. Data in Table 1 that cover the period 1960-2017 are: real government consolidated gross debt-to-real GDP ratio, D, real credit to the private non-financial sector-to-real GDP ratio, B, real GDP, Y, and real government final consumption expenditure, G. Real GDP and the GDP deflator were collected from the European Commission's AMECO Database. Real public debt is the deflated series of the nominal general government consolidated gross debt obtained from AMECO for Spain and Germany, and of the nominal total federal debt from the Federal Reserve of St. Louis' FRED Database for the US. Data on real private debt was generated by deflating the nominal series available at the Bank of International Settlements (BIS) on credit, from all sectors of the economy, to the private non-financial sector (non financial corporations, households and non-profit institutions serving households), adjusted for breaks. Real public spending is the deflated series of OECD data on nominal total general government expenditure.

For the comparison of the data I detrend both the real GDP and the real public consumption applying the Hodrick Prescott filter. To evaluate real private and public debt we use their ratio over real GDP.

Appendix B

Contract between financial intermediary and entrepreneur

The model includes a productivity shock ω_{t+1}, lognormally distributed with a cumulative distribution function, $F(\omega, \sigma_{\omega,t})$, being $\mu_{\omega,t}$ the average and $\sigma_{\omega,t}$ the standard deviation of the distribution where $E_t\omega_{t+1} = 1$. From the properties of the lognormal distribution:

$$E_t\omega_{t+1} = e^{\mu_{\omega,t}+\frac{1}{2}\sigma^2_{\omega,t}} \Rightarrow e^{\mu_{\omega,t}+\frac{1}{2}\sigma^2_{\omega,t}} = 1 \Rightarrow \mu_{\omega,t} + \frac{1}{2}\sigma^2_{\omega,t} = 0 \Rightarrow \mu_{\omega,t} = -\frac{1}{2}\sigma^2_{\omega,t}.$$

To obtain the loglinearized version of the model I use the following equations that are also derived from the properties of the lognormal distribution:

$$\Gamma(\varpi_{t+1}, \sigma_{\omega,t}) = \varpi_{t+1}(1 - F(\varpi_{t+1}, \sigma_{\omega,t})) + G(\varpi_{t+1}, \sigma_{\omega,t}),$$

$$\Gamma_\omega(\varpi_{t+1}, \sigma_{\omega,t}) = 1 - F(\varpi_{t+1}, \sigma_{\omega,t}),$$

$$G(\varpi_{t+1}, \sigma_{\omega,t}) = 1 - \phi\left(\frac{\frac{1}{2}\sigma^2_{\omega,t} - \log\varpi_{t+1}}{\sigma_{\omega,t}}\right),$$

and

$$G_\omega(\varpi_{t+1}, \sigma_{\omega,t}) = \varpi_{t+1}F_\omega(\varpi_{t+1}, \sigma_{\omega,t}).$$

Appendix C

Entrepreneur's problem with macroprudential policy

We solve again the problem of the entrepreneur introducing the macroprudential tool in the zero profit condition of the financial intermediary. Therefore, we have that:

$$\frac{R_{t+1}^k}{R_t}\left[\varpi_{t+1}\left[1-F\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]+\left(1-\mu\right)\int_0^{\varpi_{t+1}}\omega dF\left(\omega,\sigma_{\omega,t}\right)\right]q_t k_t=\eta_t\frac{b_t}{p_t}, \quad \text{(C.1)}$$

and taking into account the properties of the lognormal distribution, we now write the zero profit condition of the financial intermediary as:

$$\frac{R_{t+1}^k}{R_t}\left[\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]q_t k_t=\eta_t\frac{b_t}{p_t}. \quad \text{(C.2)}$$

The problem of maximization of the entrepreneur's expected networth requires choosing both the ratio of leverage and the schedule for ϖ_{t+1}:

$$\max_{\frac{\frac{b_t}{p_t}}{n_t},\varpi_{t+1}} \frac{R_{t+1}^k}{R_t}\left[1-\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]\left(1+\frac{\frac{b_t}{p_t}}{n_t}\right), \quad \text{(C.3)}$$

subject to the zero profit condition of the financial intermediary,

$$\left[\frac{R_{t+1}^{k}}{R_t}\left[\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]\left(1+\frac{\frac{b_t}{p_t}}{n_t}\right)-\eta_t\frac{\frac{b_t}{p_t}}{n_t}\right]. \tag{C.4}$$

After maximizing the previous expression we get two first order conditions with ξ_t as the Lagrangian coefficient:

$$E_t\frac{R_{t+1}^{k}}{R_t}\left[1-\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]+\xi_t\left\{\frac{R_{t+1}^{k}}{R_t}\left[\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]-\eta_t\right\}=0, \tag{C.5}$$

and

$$-\Gamma_{\omega}\left(\varpi_{t+1},\sigma_{\omega,t}\right)+\xi_t\left[\Gamma_{\omega}\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]=0. \tag{C.6}$$

From this last first order condition we can write the Lagrangian as:

$$\xi_t=\frac{\Gamma_{\omega}\left(\varpi_{t+1},\sigma_{\omega,t}\right)}{\Gamma_{\omega}\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)}= \frac{1-F\left(\varpi_{t+1},\sigma_{\omega,t}\right)}{1-F\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu\varpi_{t+1}F_{\omega}\left(\varpi_{t+1},\sigma_{\omega,t}\right)}, \tag{C.7}$$

and then rewriting we get:

$$E_t\frac{R_{t+1}^{k}}{R_t}\left[1-\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]= E_t\left[\frac{1-F\left(\varpi_{t+1},\sigma_{\omega,t}\right)}{1-F\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu\varpi_{t+1}F_{\omega}\left(\varpi_{t+1},\sigma_{\omega,t}\right)}\right] \left\{\eta_t-\frac{R_{t+1}^{k}}{R_t}\left[\Gamma\left(\varpi_{t+1},\sigma_{\omega,t}\right)-\mu G\left(\varpi_{t+1},\sigma_{\omega,t}\right)\right]\right\}, \tag{C.8}$$

what combined with the zero profit condition of the financial intermediary gives:

$$E_t \frac{R^k_{t+1}}{R_t} \left[1 - \Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right] = \\ E_t \left[\frac{1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right)}{1 - F\left(\varpi_{t+1}, \sigma_{\omega,t}\right) - \mu \varpi_{t+1} F_\omega\left(\varpi_{t+1}, \sigma_{\omega,t}\right)}\right] \eta_t \frac{n_t}{q_t k_t}, \quad \text{(C.9)}$$

also written as:

$$q_t k_t = \left[\frac{\xi_t \eta_t}{E_t \frac{R^k_{t+1}}{R_t} \left[1 - \Gamma\left(\varpi_{t+1}, \sigma_{\omega,t}\right)\right]}\right] n_t. \quad \text{(C.10)}$$

Finally, the average net wealth of the entrepreneur, taking into account the macroprudential instrument, becomes:

$$n_t = \gamma^e \frac{1}{\Pi_t} \left\{\left[1 - \mu G\left(\varpi_t, \sigma_{\omega,t-1}\right)\right] R^k_t q_{t-1} k_{t-1} - R_{t-1} \frac{b_{t-1}}{p_{t-1}} \eta_t\right\} + w^e. \quad \text{(C.11)}$$

Appendix D

Equilibrium loglinearized equations of the model

The final loglinearized equations of the model without macroprudential policy can be found in Fernández Villaverde (2010). When macroprudential policy is introduced in the model the following equations differ from those of the baseline model and a new equation is included for the macroprudential tool. We assume two possible characterizations for the latter that depend on the definition of Ψ_t.

Equation for wealth evolution:

$$\widehat{n}_t = a_1\left(-\widehat{\Pi}_t\right) + a_2\left(\omega_c\widehat{\overline{\omega}}_t + \sigma_c\widehat{\sigma}_{\omega,t-1}\right) + a_3\left(\widehat{R}^k_t + \widehat{q}_{t-1} + \widehat{k}_{t-1}\right) + a_4\left(\widehat{R}_{t-1} + \widehat{\eta}_{t-1} + \widehat{\overline{b}}_{t-1}\right), \quad \text{(D.1)}$$

with,

$$a_1 = \frac{\gamma^e}{\Pi n}\left[\left(1-\mu G\left(\varpi\right)\right)R^k k - R\bar{b}\eta\right],$$

$$a_2 = -\frac{\gamma^e}{\Pi n}\mu G\left(\varpi\right)R^k k,$$

$$a_3 = \frac{\gamma^e}{\Pi n}\left(1-\mu G\left(\varpi\right)\right)R^k k,$$

and

$$a_4 = -\frac{\gamma^e}{\Pi n} R\bar{b}\eta.$$

Equation 1 for entrepreneur:

$$E_t\widehat{R}^k_{t+1} - \widehat{R}_t + \omega_a E_t\widehat{\varpi}_{t+1} + \sigma_a\widehat{\sigma}_{\omega,t} = \widehat{n}_t - \widehat{q}_t - \widehat{k}_t + \widehat{\eta}_t. \tag{D.2}$$

Equation 2 for entrepreneur:

$$\widehat{R}^k_t - \widehat{R}_{t-1} + \omega_b\widehat{\bar{\omega}}_t + \sigma_b\widehat{\sigma}_{\omega,t-1} = \widehat{\bar{b}}_{t-1} - \widehat{q}_{t-1} - \widehat{k}_{t-1} + \widehat{\eta}_t. \tag{D.3}$$

Equation for Macroprudential instrument that depends on nominal credit growth:

$$\widehat{\eta}_t = \gamma_\eta\left(\widehat{\bar{b}}_t - \widehat{\bar{b}}_{t-1} + \widehat{\Pi}_t\right). \tag{D.4}$$

Equation for Macroprudential instrument that depends on credit-to-GDP ratio:

$$\widehat{\eta}_t = \gamma_\eta\left(\widehat{\bar{b}}_t - \widehat{y}_t\right). \tag{D.5}$$

Notice that in the last two equations variable $\widehat{\Psi}_t$ is replaced by the variables that define it.

Appendix E

Alternative analysis for non-coordinated macroprudential policy

Figures 2.5 and 2.6 compare the no macroprudential and the country-targeted macroprudential cases with two alternative scenarios. Both consist of the implementation of a country-targeted toolkit but in a non-coordinated way, that is, only one of the countries implement macroprudential policy: the Home country macroprudential scenario is represented by the dotted line and the Foreign country macroprudential scenario by the dash-dotted line. The dashed line represents the country-targeted macroprudential scenario in which both countries implement macroprudential measures and the solid line the no macroprudential scenario.

E.1 Macroprudential policy at the Home country

The home country is not affected by what the foreign country does, that is it does not care about coordination. Therefore, for the home country this non-coordinated scenario is equivalent to the case in which both countries implement macroprudential policy. The foreign country however attains more stability when the home country is the only one that applies macroprudential policy. In this case the foreign country is

even more stabilized than when both countries undertake macroprudential measures. This situation can lead the foreign country to free-ride.

E.2 Macroprudential policy at the Foreign country

As mentioned previously, the home country is not affected by what the foreign country does, so for the home country this non-coordinated scenario is equivalent to the no macroprudential policy case. By constrast, the foreign country attains more stability than in the no macroprudential scenario but less stability than in any other case.

Bibliography

Angelini, P., S. Neri, and F. Panetta (2012): "Monetary and Macroprudential Policies," ECB Working papers series Num. 1449, July 2012, European Central Bank.

Angelini, P., S. Neri, and F. Panetta (2014): "The interaction between capital requirements and monetary policy," *Journal of Money, Credit and Banking,* vol. 46, no. 6, September: 1073-1112.

Benigno, P. and M. Woodford (2012): "Linear-Quadratic Approximation of Optimal Policy Problems," *Journal of Economic Theory,* 147 (1), pp. 1-42.

Bernanke, B. S., M. Gertler and S. Gilchrist (1999): "The financial accelerator in a quantitative business cycle framework," in *Handbook of Macroeconomics*, ed. by J.B. Taylor, and M. Woodford, Vol. 1, Chap. 21, pp. 1341-1393. Elsevier.

Bordo, M. and J. Haubrich (2012): "Deep recessions, fast recoveries and financial crises: Evidence from the American record," NBER Working Paper No 18194 (June 2012). National Bureau of Economic Research.

Bordo, M. (2014): "TARGET balances, Bretton Woods, and the Great Depression," VOX CEPR Policy Portal (March 2014).

Boscá, J.E., R. Doménech, J. Ferri, R. Méndez, J.F. Rubio-Ramírez (2018): "Financial and Fiscal Shocks in the Great Recession and Recovery of the Spanish Economy," in BBVA Research Working paper, 18/08.

Bozio, A., C. Emmerson, A. Peichl and G. Tetlow (2015): "European Public Finances and the Great Recession: France, Germany, Ireland, Italy, Spain and the United Kingdom Compared," *Fiscal studies*, vol. 36, no. 4, pp. 405-430 (2015) 0143-5671.

Brzoza-Brzezina, Kolasa and Makarski (2015): "Macroprudential policy and imbalances in the euro area," *Journal of International Money and Finance*, vol. 51(C), pp. 137-154.

Cerutti, E., S. Claessens and L. Laeven (2015): "The Use and Effectiveness of Macroprudential Policies: New Evidence," IMF Working Paper No. 15/61, International Monetary Fund.

Christiano, L., R. Motto and M. Rostagno (2010): "Financial factors in economic fluctuations," ECB Working papers May1192, European Central Bank.

Christiano, L., M. Eichembaum and S. Rebelo (2011): "When is the government spending multiplier large?," *Journal of Political Economy*, Vol. 119, No. 1 (February 2011), pp. 78-121.

Claessens, S. (2014): "An Overview of Macroprudential Policy Tools," IMF Working Paper No. 14/214, International Monetary Fund.

Corsetti, G. (2007): "New open economy macroeconomics," EUI Working Paper 2007/27, European University Institute.

Corsetti, G., K. Kuester, A. Meier and G. Müller (2012): "Sovereign Risk, Fiscal Policy, and Macroeconomic Stability," IMF Working Paper No. 12/33, International Monetary Fund.

Davig, T. (2018): "'Discussion of 'Tracking Monetary-Fiscal Interactions across Time and Space'," *International Journal of Central Banking,* June 2018, pp. 229-236.

Davig, T. and E.M. Leeper (2011): "Monetary–fiscal policy interactions and fiscal stimulus," *European Economic Review*, 55(2), 211–227.

de Paoli, B. and M. Paustian (2013): "Coordinating Monetary and Macroprudential Policies," FRB of New York Staff Report No. 653.

Dehmej, S. and L. Gambacorta (2017): "Macroprudential Policy in a Monetary Union," Working paper No. 3, Bank Al-Maghrib.

Engel, C. (2003): "Expediture switching and exchange rate policy," *NBER Macroeconomics Annual* 2002 (January 2003), 17, 231-272. National Bureau of Economic Research.

Estrada, A. and J. Saurina (2016): "Spanish boom-bust and macroprudential policy," *Revista de Estabilidad Financiera* nº 30 pp. 37-61. Banco de España.

European Systemic Risk Board (2013): "Recommendation of the European Systemic Risk Board of 4 April 2013," *Official Journal of the European Union* (ESRB/2013/1) (2013/C 170).

Faia, E. (2001): "Stabilization policy in a two country model and the role of financial frictions," ECB Working papers April n 56. European Central Bank.

Fernández-Villaverde, J. (2010): "Measuring the effects of fiscal policy in a model with financial frictions," Mimeo, `http://economics.sas.upenn.edu/~jesusfv/ff.pdf`.

Fernández Villaverde, J. (2010): "Fiscal policy in a model with financial frictions," *American Economic Review* Vol. 100, No. 2 (May 2010), pp. 35-40.

Fernández-Villaverde, J. (2012): "A model with costly-state verification," Lecture Notes on Macroeconomics and Financial Frictions, `http://economics.sas.upenn.edu/~jesusfv/teaching.html`.

Ferrero, A. (2005): "Fiscal and Monetary Rules for a Currency Union," ECB Working papers series Num. 502, July 2005, European Central Bank.

Freixas, X. and J. C. Rochet (2008): "Microeconomics of Banking," Second Edition. The MIT Press, Massachusetts Institute of Technology.

Galí, J. and T. Monacelli (2003): "Monetary policy and exchange rate volatility in a small open economy," *Review of Economic Studies.* 72, 707-734.

Galí, J. and T. Monacelli (2005): "Optimal monetary and fiscal policy in a currency union," NBER Working Paper No 11815 (December 2005). National Bureau of Economic Research.

Gelain, P. and P. Ilbas (2017): "Monetary and Macroprudential Policies in an Estimated Model with Financial Intermediation," *Journal of Economic Dynamics and Control*, 78, pp. 164-189.

Gerlach, S., A. Giovannini, C. Tille, and J. Viñals (2009). "Are the Golden Years of Central Banking Over? The Crisis and the Challenges," *Geneva Reports on the World Economy* 10.

Gomes, P. and H. Seoane (2018): "Made in Europe: Monetary-Fiscal Policy Mix with Financial Frictions," Working paper.

Iacoviello, M. (2005): "House prices, borrowing constraints, and monetary policy in the business cycle," *American Economic Review,* vol. 95, no. 3, June: 739-764.

International Monetary Fund (2013): "Key Aspects of Macroprudential Policy," IMF Policy Paper, June 2013.

Kannan, P., P. Rabanal and A. Scott (2012): "Monetary and Macroprudential Policy Rules in a Model with House Price Booms," *The B.E. Journal of Macroeconomics* 12 (1): 1–44.

Lambertini, L,. Mendicino, C. and Punzi, M. (2013), "Leaning against boom-bust cycles in credit and housing prices," *Journal of Economic Dynamics and Control* 37 (8), pp. 1500-1522

Leeper, E. (1991): "Equilibria under 'active' and 'passive' monetary and fiscal policies," *Journal of Monetary Economics,* Vol. 27, No. 1, pp. 129-147.

Leith, C. and S. Wren-Lewis (2006): "Compatibility Between Monetary and Fiscal Policy Under EMU," *European Economic Review*, 50(6),1529-1556.

Lim, Cheng H., F. Columba, A. Costa, P. Kongsamut, A. Otani, M. Saiyid, T. Wezel, X. Wu (2011): "Macroprudential Policy: What Instruments and How Are They Used? Lessons from Country Experiences," IMF Working Paper No. 11/238, International Monetary Fund.

Quint, D. and Q. Rabanal (2014): "Monetary and Macroprudential Policy in an Estimated DSGE Model of the Euro Area," *International Journal of Central Banking* Vol. 10, No. 2 (June 2014), pp. 169-236.

Rubio, M. (2014): "Macroprudential Policy Implementation in a Heterogeneous Monetary Union," CFCM Working paper 14/03. Centre for Finance, Credit and Macroeconomics. University of Nottingham.

Rubio, M. and J. A. Carrasco-Gallego (2014): "Macroprudential and Monetary Policies: Implications for Financial Stability and Welfare," *Journal of Banking and Finance*, 49, pp. 326-336.

Rubio, M. and J.A. Carrasco-Gallego (2016): "Coordinating macroprudential policy within the Euro Area: The case of Spain," *Economic Modelling* Vol. 59 (December 2016), pp. 570-582.

Schmitt-Grohé, S. and M. Uribe (2002): "Closing small open economy models," NBER Working Paper No 9270 (October 2002). National Bureau of Economic Research.

Schmitt-Grohé, S. and M. Uribe (2004): "Optimal simple and implementable monetary and fiscal rules," NBER Working Paper No 10253 (January 2004). National Bureau of Economic Research.